THE ŚULBASŪTRAS

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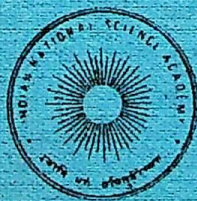
INDIAN NATIONAL SCIENCE ACADEMY
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THE ŚULBASŪTRAS

of

BAUDHĀYANA, ĀPASTAMBA, KĀTYĀYANA AND MĀNAVA

with

Text, English Translation and Commentary

by

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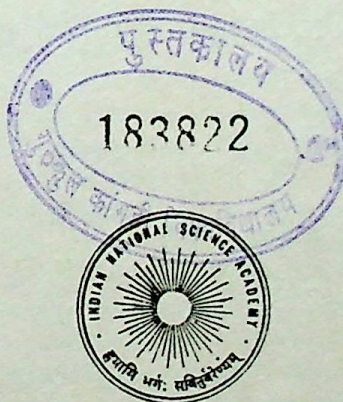
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FOREWORD

In the last century, and at the beginning of the present, George Thibaut and A. Bürk brought to the notice of the scholarly world the mathematical significance of two *sūtra* texts, namely the *Śulba-sūtras* by Baudhāyana and Āpastamba. These two works are manuals for the construction of various types of altars for fire-sacrifice, an ancient cult fully established in the time of the *Saṃhitās*. Their mathematical importance lies in a precise statement of the squared relationship of the two sides and the diagonal of a rectangle, the realization of the irrationality of numbers like $\sqrt{2}$, efforts to determine their approximate values, formulation of rules for combining rectilinear figures, transforming squares into rectangles, triangles, trapeziums and circles and vice versa, the use of simple fractions and approximate values of π. All these arose from the mensuration of laying altars of a fixed square area but of different shapes and filling them with a fixed number of bricks necessarily of different geometrical shapes. The Greek tradition of the development of geometry from the more ancient Egyptian mensuration, the rope-stretcher's art, appears to have its counterpart in the scriptural tradition of the *śulba-sūtras*. That similar tradition obtained in other culture areas has become increasingly clear with advancing knowledge of the cuneiform texts and ancient Chinese mathematical sources.

I am happy that the authors of the present monograph have presented the full critical texts and translations of the four *śulba-sūtras* by Baudhāyana, Āpastamba, Kātyāyana and Mānava and modern commentaries on them. A carefully prepared introduction has dealt with: the genesis of these texts as part of the ritual literature *(Kalpasūtras)* constituting one of the six *Vedāṅgas*; the vexed question of the antiquity of these *sūtras*; the philosophical significance of performing fire sacrifices on various types of altars; and other related questions. Regarding the dating of Baudhāyana, Mānava, Āpastamba and others a balanced view has been maintained between the opinions of European sanskritists like Bühler, Keith, Macdonell, Renou and Filliozat and those of Indian scholars like Kane and Ramgopal. Though the date of Baudhāyana, the earliest of *sūtra* writers, still varies over a range of two to three centuries, there is no doubt that the tradition of altar construction and the related sacrifices goes back to the period of the *Saṃhitās* and the *Brāhmaṇas* antidating the *sūtras,* as the numerous passages in the *Taittirīya, Maitrāyaṇī,* and *Kapiṣṭhala Saṃhitās* and the *Śatapatha* and other *Brāhmaṇas* amply indicate.

From its very inception the National Commission for the Compilation of History of Sciences in India has laid emphasis on the study of primary source materials. In astronomy and mathematics such materials are abundant. In 1966, the same two scholars along with a third carried out a bibliographical study of

Sanskrit works on astronomy and mathematics. This has been followed by critical editions, translations and commentaries of the works of Āryabhaṭa and Lalla by a number of scholars working for the National Commission. Now we have the *śulba* texts in the same series. We look forward to several such studies of our rich primary sources with a view to evolving a better understanding of the development of the various sciences in ancient and medieval India.

Planning Commission
Yojana Bhavan
New Delhi
14 December 1983

M. G. K. Menon

PREFACE

The present monograph on the *śulbasūtras* by Baudhāyana, Āpastamba, Kātyāyana and Mānava was planned by the History of Science Unit established at Calcutta by the History of Science Board of the Indian National Science Academy (then called the National Institute of Sciences of India) and continued by the National Commission for the Compilation of History of Sciences in India. The Unit under the supervision of one of us (S.N.S.), with which the other author (A.K.B.) was then associated as a Research Scholar, functioned at first at the Asiatic Society and subsequently at the Calcutta office of the Academy in the same premises of the Society. This happy location permitted the free and frequent use of the Society's rich library and its manuscript holdings. The authors also had the opportunity of consulting the MS No. Th. 184 of the *Mānava-śulba* kept at the National Library, Calcutta and a microfilm transcription of the MS. No. 536 of the same text available at the Bombay Branch of the Asiatic Society. We express our sincere thanks to the Librarians of the Asiatic Society and the National Library, Calcutta and the Bombay Branch of the Asiatic Society for permitting us to make use of the aforesaid manuscripts in their respective holdings. We also place on record that late Nagendranath Vedantatirtha, Curator of the Asiatic Society rendered us his ungrudging help in elucidating some of the difficult passages of the *sūtras,* particularly of the *Mānava-śulba*. We further express our grateful thanks to the Academy for providing a Senior Research Fellowship to one of us (A.K.B.) and contingent grants to meet the expenses of the project.

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INTRODUCTION

The *Vedāṅgas,* that important group of literature often referred to as the appendages of the *Vedas,* constitute an important source in the history of science in ancient India. This is evident from such subjects as phonetics *(śikṣā)*, ritual *(kalpa)*, grammar *(vyākaraṇa)*, etymology *(nirukta)*, metrics *(chanda)* and astronomy *(jyotiṣa)*. These branches of study arose within the Vedic schools themselves as a necessary condition for mastering the *Vedas*. This class of literature was written in the *sūtra* or aphoristic style, a form of expression characterized by great precision, brevity and economy of words, the like of which is not met with in the entire literature of the world. The style has been developed to sum up only the pith of the learning in short sentences using nouns often compounded at great length and avoiding the use of verbs as far as possible. The style became a dominant feature of the various branches of the *Vedāṅgas* and was also adopted by the writers of the *Arthaśāstra,* the *Kāmaśāstra,* the *Nāṭyaśāstra* and so on.

The *Kalpasūtras,* concerned principally with the rituals constituting the chief contents of the *Brāhmaṇas,* are supposed to be the first *Vedāṅga* to have received systematic treatment.[a] The *Kalpasūtras* are again available in four different classes, e.g. the *śrauta*, the *gṛhya,* the *dharma* and the *śulba*. The *Śrautasūtras* deal with *śrauta*-sacrifices abundantly discussed in the *Brāhmaṇas* and are naturally concerned with direction for the laying of the sacrificial fires for the fire-sacrifice *(agnihotra)*, the new and the full-moon, the seasonal, the *soma* and other sacrifices. These are, as Winternitz has pointed out, our most important source for the understanding of the Indian sacrifice-cult. Through their preoccupation with the laying and construction of the various sacrifical altars and fires, these also constitute an important source of Vedic, and possibly the earliest, mathematics in India. Of special importance as far as concerns mathematics, geometry in particular, are the *Śulbasūtras* which are sometimes classified as a separate branch of the *Śrautasūtras,* but which are often found attached to the *Śrautasūtras*.

The *Śulbasūtras* are of special importance because these deal specifically with rules for the measurements and constructions of the various sacrificial fires and altars and consequently involve geometrical propositions and problems relating to rectilinear figures, their combinations and transformations, squaring the circle and circling the square as well as arithmetical and algebraic solutions of problems arising out of such measurements and constructions. The word *śulba* (also spelt as *śulva)* means a 'cord', a 'rope' or a 'string', and its root *śulb* signifies 'measuring' or 'act of measurement'.[b] It is interesting to note that, among the Egyptians, geometry of surveying was considered to be the science of the 'rope-stretchers' *(harpedonap'tae)* who thus appear to be the Egyptian counterpart of the Indian *śulbavids*.

a Winternitz, I, pt. 1, 237; also see Sen, chapter on 'A Survey of Source Materials', *A Concise History of Science in India*, p. 23-24

b Datta (2), 8.

Quite appropriately, therefore, the *Śulbasūtras* represent the *Brāhmaṇa* geometry or mensuration, the *śulba-vijñāna,* as mentioned in the *Mānava* and other *śulbas* and in their commentaries. It is also evident that the *śulbavid,* the expert geometer was held in high esteem in the learned priestly circles.

Since *Śulbasūtras* form part of the *Śrautasūtras,* inspite of their separate classification under the *Kalpasūtras,* one would expect a *śulba* section attached to each *Śrautasūtra*. And there are *Śrautasūtras* belonging to all the four *Saṃhitās*. But what we possess today are a small number of *Śulbasūtras* attached to the *śrautas* belonging only to the various schools of the *Yajurveda*. Of them the Black Yajurvedins of the *Taittirīya* school were the most active and prolific producers of the *sūtra* text, and it is no wonder that the most comprehensive, as also the largest number of, *Śulbasūtras* were produced by the scholars of this school, such as Baudhāyana, Āpastamba, Vādhula and Hiraṇyakeśin. Of the *Maitrāyaṇī* school, Mānava and Vārāha are known to have written works on the *śulba*. In this subject *Kāṭhaka-Kapiṣṭhala* school is represented by Laugākṣī. Of the White Yajurvedins, Kātyāyana, another prolific writer of the *sūtras* is credited with a small but scientifically executed *śulba* work. Maśaka, the *sūtrakāra* of the *Sāmaveda* school probably also compiled a *śulba* text attached to the *Śrautasūtras* of that school. The initiative of the Yajurvedins in producing works of this kind is not surprising when we bear in mind that they were the principal custodians of the knowledge of sacrificial formulas and specialized in sacrificial performances.

Of these various *śulba* works, those due to Baudhāyana, Āpastamba, Kātyāyana and Mānava are best known, and others are known through references. We tried to locate manuscripts of some of these latter ones, but without success and had to be content with the *Śulbasūtras* by the four aforesaid scholars. The need for a monograph dealing with the different *Śulbasūtras,* in one volume so as to present a comprehensive view of the subject, inspite of the excellent studies of some of these texts by distinguished scholars, has long been felt, and has been further reinforced by the fact that the works of Thibaut and Bürk published towards the end of the 19th and the beginning of the present century are now very difficult to obtain. That the works of Thibaut and Bürk constituted the main inspiration of our humble efforts presented in these pages need hardly be overestimated.

Place and Time of the Authors of the Śulbasūtras

There is a good deal of uncertainty and differences of opinion about the place and time of the *śulbakāras*. The *Śrautasūtras* and the *Śulbasūtras* are silent about these questions as are other Vedic and post-Vedic texts. Georg Bühler who considered the question of date and time of Baudhāyana and Āpastamba was inclined to believe that both of them hailed from the Andhra country.[a] He argued that the followers of Baudhāyana and Āpastamba had lived in south India since early times, that Baudhāyana manuscripts had been found in the south, and that the *Mahārṇava,* an early work mentioned Andhra country as the native place of Āpastamba. Bühler

[a] Bühler, *SBE*, 14, pp. xliii; 2, pp. xxx.

also pointed out that the name of Āpastamba had been found on several land-grants of the south and that both Baudhāyana and Āpastamba referred in their *Dharma-sūtras* to the manners and customs of the people of their times inhabiting the northern parts of India,—a reference rather unusual for authors hailing from the north. Recently Ramgopal has shown that, in their *Śrautasūtras* and *Dharmasūtras*, Baudhāyana gave ample evidence of his close familiarity with *Āryāvarta*, the doab between the Ganges and the Yamuna and its surroundings and Āpastamba with Kurupāñcāla country and its vicinity.[a] About the places of origin of Kātyāyana, Mānava and other *śulbakāras*, nothing definite can be said.

If their native places are open to question so are their dates. Bühler placed Āpastamba around the fifth century B.C. but did not himself consider this date as conclusive or anything more than tentative. He was only definite that both Baudhāyana and Āpastamba had lived before the third century B.C. Between these two *sūtrakāras*, all scholars agree, Baudhāyana is anterior to Āpastamba.

Instead of working downwards from the high antiquity of Baudhāyana and Āpastamba whatever that antiquity might be, other scholars have preferred to consider the dates of later writers like Pāṇini, Kātyāyana, and Patañjali and work upwards to arrive at the dates of Baudhāyana and Āpastamba. Here again, Pāṇini's date itself is debatable and no better datable than other ancient texts. Nevertheless, scholars are generally agreed that Pāṇini most probably lived in the fourth century B.C. Keith argued that Pāṇini's date depended essentially on the date to be assigned to the *Mahābhāṣya* of Patañjali. Renou and Filliozat and Keith placed Patañjali's date around *c.*150 B.C. on the ground that the *Mahābhāṣya* referred to a sacrifice by Puṣyamitra who reigned around *c.* 185 or 178 B.C.[b] In his *Veda of the Black Yajurveda*, Keith has observed that by 140 B.C. Pāṇini's work attained a commanding position as is evident by the clear proof of the elaborate way in which it was commented upon in Dākṣāyaṇa's *Saṃgraha*, by Kātyāyana and others and concluded that Pāṇini's date could hardly by any chance be later than 300 B.C., nor there could be any reason to deny that he might have lived about 350 B.C.

This brings us to the date of Kātyāyana who flourished after Pāṇini and before Patañjali. Admitting that there is no direct proof, Keith suggested 250 B.C. as the most probable date for Kātyāyana. Eggeling, on the other hand, placed Kātyāyana in the fourth century B.C. after considering a still earlier date for Pāṇini.[c] Macdonell, in his *Bṛhaddevatā*[d] favoured a date *c.* 350 B.C. for Kātyāyana, more or less in agreement with Eggeling.

Bühler, Keith and other scholars all agreed that the irregular forms persistently used by Baudhāyana and Āpastamba in composing the whole texts of the *Śrauta-*, the *Gṛhya-* and the *Dharma-sūtras* could have hardly been possible after Pāṇini's grammar reached its accepted position. Bühler, therefore, considered Āpastamba

a Ramgopal, 93-100.
b Renou and Filliozat, 86-91; Keith (2), 426-28; Keith (1), Preface clxviii to clxxii.
c *SBE*, 12, xxxix.
d I, p, xxii

anterior to Pāṇini by about 150-200 years, which would place the former in the fifth-sixth century B.C. In his *Āpastamba Śrautasūtra,* Garbe, in general agreement with Bühler, assigned Āpastamba to the fifth century B.C. Keith considered such a high date for Āpastamba improbable from consideration of language and would not take him beyond say 300 or 350 B.C. By Keith's own agreement with Bühler that Āpastamba could be anterior to Pāṇini and his statement that there is absolutely no conclusive evidence of the date of these early *sūtrakāras,* it is somewhat baffling to understand how Āpastamba could be placed around *c.* 350 B.C.

Regarding Baudhāyana and Mānava, both have been considered definitely older than Āpastamba, as their archaic style of writing would indicate. Mānava whose works were used by Āpastamba wrote more or less in the *Brāhmaṇa* style, and Richard Garbe considered his *sūtra* as the oldest, but that, as Keith points out, was before the text of Baudhāyana was known. Baudhāyana's archaic *Brāhmaṇa* style, is clearly discernible in his *uttarati* as also in all his *sūtra* writings. Considering all this, Keith's conservative estimate for Baudhāyana's date was fifth century B.C. while Caland was prepared to place him in the sixth century B.C. in his *Über das Rituelle Sūtra des Baudhāyana.*[a] Mānava doubtless should be placed somewhere between Baudhāyana and Āpastamba. P. V. Kane in his *History of Dharmasūtras* dated the *Śrautasūtras* of Baudhāyana, Āpastamba and Kātyāyana between 800 B.C. and 400 B.C. Ramgopal who considered the sequence between Baudhāyana and Āpastamba, Āpastamba and Pāṇini, Pāṇini and Kātyāyana and Kātyāyana and Patañjali, more or less agreed with Kane and concluded that the principal *sūtras* were composed between *c.* 800 B.C. and 500 B.C.

The foregoing discussion will make it abundantly clear that we are still far from narrowing the date range differing by centuries and putting the early *sūtra* works on a firmer chronological basis. What is generally accepted is this relative chronological position in order of anteriority, e.g. Baudhāyana, Mānava, Āpastamba, Pāṇini, Kātyāyana. Hiraṇyakeśī, Vārāha, Vādhula and so on. This is also somewhat borne out by the tradition of the *Taittiriya* school which would place the early *sūtrakāras* in the following order of age: Baudhāyana, Bharadvāja, Āpastamba, Satyāṣāḍhā, Hiraṇyakeśin and Vaikhānasa. Whatever date one might wish to assign to the *Kalpasūtras,* the *Śrautasūtras* and the *Śulbasūtras,* we must agree with Thibaut that these *sūtras* only give a systematized account of sacrificial rites which had been practised during long preceding ages.[b] The rules for the sides of the various altars, detailed arrangement of the sacrificial ground, the positioning of the fires, altars, tents and sheds, the shapes of the fire-altars in the form of the falcon and other birds are all mentioned and discussed in various ways and at various places in the *Brāhmaṇas* as we shall see in what follows. The manner in which the measurements and transformations had to be carried out, in other words, the geometry and mensuration involved in their construction, it is true, are not discussed in the *Brāhmaṇas* and cannot be expected either in this class of literature. But there can hardly be any doubt that what Baudhāyana, Āpastamba, Mānava, Kātyāyana

[a] pp. 7 ff.
[b] Thibaut (1) pt. 1, 270

and others tried to codify in a systematic manner in their *Śulbasūtra* manuals must have for a long time formed the common property of all *adhvaryus* and priests specialized in the performance of sacrificial rites.

References to Sacrificial Altars and Fires in Saṃhitās and Brāhmaṇas

The Vedic cult knew no temple. The ceremonies were performed either in the sacrificer's house or on a nearby plot of ground. This ground must be flat and covered with grass. For the performance of sacrifices, certain *vedis* and *agnis* had to be constructed. A *vedi* is a specified raised area on which the sacrifice is to be performed and on which persons performing the ceremony, namely the sacrificer, the *hotā*, the *adhvaryu*, the *ṛtvik* and others are to take their seats. Some of the main *vedis* include *the mahāvedi*, the *darśapūrṇamāsa vedi*, the *śautrāmaṇi vedi*, the *paitṛki vedi*, the *uttara vedi*, and the *aśvamedha vedi*. An *agni* is a raised altar, generally made of bricks, for keeping the fire. The fire-altars were of two types, the *nitya* (or perpetual) and the *kāmya* (or optional). The three perpetual fire-altars were the *gārhapatya*, the *āhavanīya* and the *dakṣiṇāgni* and meant for daily sacrifices. The *kāmya agnis* intended for wish fulfilment, included the *śyenacit*, the *vakrapakṣa-vyasta-puccha-śyena*, the *kaṅkacit*, the *alajacit*, the *praugacit*, the *ubhayata praugacit*, the *droṇacit*, the *rathacakracit*, the *śmaśānacit*, the *kūrmacit*, and so on.

The mention of the *gārhapatya* fire occurs at several places in the *Ṛg-veda*.[a] In another place, there is a reference to three places *(trisadhasthe)* of the *agni*, implying the *gārhapatya*, the *āhavanīya* and the *dakṣiṇāgni*[b]. A reference to the form of *śyena* is found in the *Ṛg-veda* where *agni* is frequently called a bird *(vayas)*[c]. The *Ṛg-veda* also contains references to altars and their constructions of which a few examples are as follows: 'Let the priests decorate the altar *(vedi)*, let them kindle the fire to the east[d]' 'May the measure-lengths *(yūpa)* of the sacrificial posts be to our felicity; may the sacred grass *(oṣadhi)* be (stream) for our happiness; may the altar *(vedi)* be (raised for) our happiness'[e].

In the *Taittiriya Saṃhitā*,[f] it is so ordained that the *gārhapatya citi* is to be constructed with 21 bricks arranged in an identical manner. Similar passages are found in the *Maitrāyaṇī Saṃhitā*, *Kāṭhaka Saṃhitā* and the *Kapiṣṭhala Saṃhitā*.[g] In the *Taittiriya Saṃhitā*, it is said,[h] "He who constructs (the *gārhapatya citi)* for the first time should construct in five layers................................He who constructs for the second time should construct in three layers..................". The *saumiki vedi*

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a *gārhapatyena santya ṛtunā* (*RV*. 1.15.12); *asthurino gārhapatyāni santu* (*RV*. 6.15.19); *iha priyaṃ prajayā to samṛdhyatāmasmingṛhe gārhapatyāya jāgṛhi* ; *enā patyā tanvaṃ saṃ sṛjasvādhā jivṛi vidathamā vadāthaḥ* (*RV*. 10.85.27)

b *jajñasya ketuṃ prathamaṃ purohitamagniṃ naratriṣadhasthe samidhire* (*RV*. 5.11.2).

c *RV*. 1. 164.52; 10.14.5. Compare also with 1.58.5; 1.41.7; 2.2.4; 6.3.7; 10.8.3 etc.

d *araṃ kṛṇvantu vediṃ samagnimindhatāṃ puraḥ* (*RV* 1.170. 4).

e *śaṃ na soma bhavatu brahma śaṃ naḥ śaṃ no grāvāṇaḥ śamu santu yajñāḥ śaṃ naḥ svarūṇāṃ mitavo bhavantu śaṃ naḥ prasvaḥ śamvasu vediḥ* (*RV* 7. 35. 7).

f *pratiṣṭhyā vā ekaviṃśaḥ pratiṣṭhā gārhapatyā ekaviṃśasvaiva pratiṣṭhyāṃ gārhapatyamanu prati tiṣṭhati* (*Taitt. S*. 5. 2. 3. 5).

g *Mait. S*. 3. 2. 3; *Kāṭh. S*. 20. 1; *KPS*. 32. 3.

h *pañcacitikaṃ cinvīta prathamaṃ cinvānaḥ...........tricitikaṃ cinvīta dvitīvaṃ cinvāna*...........(*Taitt. S*. 5. 2. 3. 6).

(also called *mahāvedi*), as described in the *Taittirīya Saṃhitā*, is in the form of an isosceles trapezium having its face 24 *prakramas* (or *padas*) long, base 30 *prakramas* and altitude 36 *prakramas*.[a] The measures are also given in other *saṃhitās*[b]. Although elaborate descriptions of rites and ceremonies in connection with the construction of the various altars such as the *dārśapaurṇamāsa vedi*, the *uttara vedi*, the *āgnīdhrīya* the *hotrīya*, the *mārjālīya*, the *sadas* (tent), the *uparavas* etc. are found in the *Taittirīya* and other *saṃhitās*, their measurements and constructional details are rarely given.

The standard form of an optional fire-altar was that of a certain bird. This bird was called *śyena* in the *Taittirīya Saṃhitā*[c] and *suparṇa garutman* or well winged eagle in the *Vājasaneya Saṃhitā*.[d] The spatial magnitudes of the falcon-shaped fire-altar were also given in almost all the earlier works from the *Taittirīya Saṃhitā* onwards. The measurements were made with units like *aratni, vyāma, puruṣa* etc. The area on which these fire-altars were drawn covered 7½ sq. *puruṣas*.[e] A complete list of the various *kāmya agni* together with a statement of the objects for the attainment of which each of them has to be constructed, as found in the *Taittirīya Saṃhitā*,[f] is given below :

Agni	Desired objects
Chandaścit (in the form of bird)	Desiring cattle
Śyenacit (-do-)	,, heaven
Kaṅkacit (-do-)	,, ,,
Alajacit (-do-)	Desiring support from the heaven
Prauga (in the form of an isosceles triangle)	Annihilation of rivals
Ubhayata prauga (in the form of a rhombus)	,,
Rathacakracit (in the form of a chariot wheel)	,,
Droṇacit (in the form of a trough)	Gaining food
Paricāyyacit (in the form of a circle)	Desiring a region
Śmaśānacit (in the form of a pyre) (isosceles trapezium)	Attaining the place where the forefathers have gone *(pitṛloka)*.

a *triṃśat padāni paścāt tiraścī bhavati ṣaṭtriṃśat prācī, caturviṃśatiḥ purastāt, tiraścī daśadaśa saṃpadyate* (*Taitt. S.* 6. 2. 4. 5).

b *Mait. S.* 3. 8. 4 ; *Kāṭh. S.* 25. 3 ; *KPS.* 3. 8. 6.

c *Taitt. S.* 5. 4. 11. 1.

d *Vāj. S.* 12. 4.

e *Taitt. S.* 5. 2. 5. 1 & *Mait. S.* 3. 2. 4.

f *Taitt. S.* 5. 4. 11. 1-3.
chandaścitaṃ cinvīta paśukāmaḥ paśavo vai chandāṃsi paśumāneva bhavati, śyenacitaṃ cinvīta suvargakāmaḥ śyenovai vayasāṃ pratiṣṭha śyena eva bhūtvā suvargaṃ patati, kaṅkacitaṃ cinvīta yaḥ kāmayeta śīrṣaṇvānamuṃṣmilloke syāmiti śīrṣaṇvānevāmuṃṣmilloke bhavatyalajacitaṃ cinvīta, catuḥsītaṃ pratiṣṭhākāmascatasro diśo dikṣveva prati tiṣṭhati, praugacitaṃ cinvīta bhrātṛvyavān praiva bhrātṛvyān nudata ubhayataḥ-praugaṃ cinvīta yaḥ kāmayeta prajātān bhrātṛvyān....rathacakracitaṃ cinvīta grāmakāmo śmaśāncacitaṃ cinvīta yaḥ kāmayeta pitṛloka......(*Taitt. S.* 5. 4. 11. 1-3).

As regards the height of the *agni* and the number of bricks to be used in its construction, *Taittiriya Saṃhitā*[a] observes:

"He should pile (the fire) of a thousand (bricks) when first piling (it); this world is commensurate with a thousand; verily he conquers this world. He should pile (it) of two thousand, when piling a second time, the atmosphere is commensurate with two thousand; verily he conquers the atmosphere. He should pile (it) of three thousand; verily he conquers the yonder world. Knee-deep should he pile (it) when piling for the first time, verily with the *gāyatrī* he mounts this world; naval-deep should he pile (it) when piling for the second time, verily with the *triṣṭubh*, he mounts the atmosphere; neck-deep should he pile (it) when piling for the third time, verily with the *jagati*, he mounts the yonder world".

An expert in this science was called *agnicit* (constructor of the *agni*). The term appears in the *Taittiriya Saṃhitā*[b] and the *Maitrāyaṇī Saṃhitā*.[c]

In the *Yajurveda*, we find an elaborate and tedious rite of the *agnicayana* or the construction of the fire-altar, associated with highly speculative philosophy.[d] The same mystic significance is found in different schools of this *Saṃhitā*, e.g. the *Taittiriya*, the *Maitrāyaṇiya*, the *Kāṭhaka-Kapiṣṭhala* and the *Vājasaneya*. This shows that the *agnicayana* rite and its philosophy had already taken definite shape in the time of the *Yajurveda*. The existence of different masters of this science with independent views is also referred to in the *Taittiriya Saṃhitā*.[e]

The relative positions of the three *nitya* fires, the *gārhapatya*, the *āhavaniya* and the *dakṣiṇāgni* are also described in the *Śatapatha Brāhmaṇa*.[f] The *gārhapatya* fire is represented like a man lying on his back with head 'towards the east'. The first clear description of the *gārhapatya* as a circle of one square *vyāma* and of the *āhavaniya* as a square of the same size appears in the *Śatapatha Brāhmaṇa*.[g] The *gārhapatya* fire is to be constructed with 21 bricks.[h]

In the *Śatapatha Brāhmaṇa*, the same measure of the *mahāvedi* as given in the *Taittiriya Saṃhitā* has been adopted.[i] The *kāmya agnis* such as the *suparṇa garutman*, the *droṇacit*, the *rathacakracit*, the *kaṅkacit*, the *praugacit*, the *ubhayata praugacit* etc. have been described here.[j] These *kāmya citis* all measure $7\frac{1}{2}$ sq. *puruṣas*. Regarding

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a *sahasraṃ cinvīta prathamaṃ cinvānaḥ, sahasrasammito vā ayaṃ loka imameva lokamabhi jayati dvisāhasraṃ cinvīta dvitīyaṃ cinvāno, dvisāhasraṃ vā antarikṣamantarikṣamevābhi jayati, trisāhasraṃ cinvīta tṛtīyaṃ cinvānastrisāhasro vā asau lokomumeva lokamabhi jayati jānudaghnaṃ cinvīta prathamaṃ cinvāno gāyatriyaivemaṃ lokamabhyārohati nābhidaghnaṃ cinvīta dvitīyaṃ cinvānastriṣṭuvaivāntarikṣamabhyārohati grīvādaghnaṃ cinvīta tṛtīyaṃ cinvāno jagatyaivāmum lokamabhyārohati* (*Taitt. S.* 5. 6. 8. 2-3).

b *Taitt. S.* 5. 2. 5. 5-6; *TS* 5. 7. 6. 1.

c *Mait. S.* 3. 4. 8.

d Keith (1), cxxv.

e *Taitt. S.* 5. 2. 8. 1-2; 5. 3. 8. 1; 5. 5. 2. 1.

f *Śat. Br.* 1. 7. 3. 23-25.

g *Śat. Br.* 7. 1. 1. 37.

h *Śat. Br.* 7. 1. 1. 34.

i *Śat. Br.* 7. 1. 1. 1.

j *SBR.* 3. 5. 1. 1-6.

the areas of the fire-altars, the *Śatapatha Brāhmaṇa* observes, "According to one (school), *ekavidha agni* should be constructed first, then by an increment of one *(square puruṣa)* successively upto a construction of an unlimited size. But indeed the *agni* (or *Prajāpati)* was to be constructed first as *saptavidha* ($7\frac{1}{2}$ sq. *puruṣas* and then by the increment of one square *puruṣa*) in succession is to be made upto *ekaśatavidha* ($101\frac{1}{2}$ sq. *puruṣas*)"[a] Compare this with Baudhāyana's and Āpastamba's statements in their *śulbasūtras*[b] that one fold means $1\frac{1}{2}$ sq. *puruṣas*, two-fold means $2\frac{1}{2}$ sq. *puruṣas*, seven-fold means $7\frac{1}{2}$ sq. *puruṣas* and so on. This has also been explained by other *śulbakāras*.

General Characteristics of Śulbasūtras, their Geometry, Arithmetic and Algebra

In our section on 'Commentaries', we have discussed in detail the *sūtras* of the four texts by Baudhāyana, Āpastamba, Kātyāyana and Mānava. In presenting the texts, their translations and commentaries, we have not followed the chronological order in which these were written as would appear from our foregoing discussions, but in order of their importance and completeness.

Baudhāyana's *sūtras* are not only the earliest but represent the most systematic, logical and detailed treatment of the subject inspite of their archaic and highly condensed *sūtra* style. It opens with the various units of linear measurements and then develops the geometry of rectilinear figures, triangles and circles, their transformations from one type to the other, methods of arriving at areas by combination or difference of given areas, the irrational number like $\sqrt{2}$ and the value of π albeit indirectly. Then the measurements of the three perpetual fires, the *gārhapatya,* the *āhavanīya* and the *dakṣiṇāgni,* the sacrificial altars such as the *mahāvedi,* the *uttara vedi* the *sautrāmaṇi vedi,* the *paitṛkī vedi,* the *dārśapaurṇamāsika vedi,* the *paśubandha vedi,* various sacrificial fires such as the *dhiṣṇyas,* the *āgnīdhrīya,* and the *mārjālīya,* the *sadas* tent, the *havirdhāna* shed for the placement of the *soma* carts and various pits like the *utkara,* the *uparava* and the *cātvāla* are given along with their relative distances from one another. Although the plan of the sacrificial ground and placement therein of the various fires, altars, tents, sheds and pits is not described in separate *sūtras,* the manner in which their measurements, relative distances and directions for their placements are given makes it quite easy for one to visualize the picture of the sacrificial ground and at once appreciate how closely and meticulously the *śulbavid* was following the time-honoured Vedic sacrificial practices. About the fire-altars for the various wish fulfilments *(kāmyaciti),* Baudhāyana gives the measurements, constructions and methods of laying bricks of different geometrical shapes in alternate layers following the strict injunction that the edges of bricks in contiguous layers must not meet. Such fire-altars include those in the form of a falcon, both rectilinear and with curved wings and extended tail, of a kite and *alaja* bird, of an

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[a] *taddhaike, ekavidhaṃ prathamaṃ vidadhātyathaikottaramā parimitavidhānna tathā kuryāt saptavidho vā 'agre prajāpatirasṛjvata|..............saptavidhameva prathamaṃ vidadhītāthaikottaramaikaśatavidhādekaśatavidhaṃ tu nātividadhīta.................|*(*Śat. Br.* 10. 2. 3. 17-18).

[b] *Bśl.* 5.1, 5.8. *Āśl.* 8.3.

isosceles triangle and a rhombus, of a chariot-wheel without and with spokes, of a square and circular trough, of a pyre, and finally one in the form of a tortoise. The facile use of geometry presented in the opening chapters is abundantly clear in the constructional procedures of these fire-altars.

Āpastamba follows more or less the same procedure and provides the same rules and techniques; but in our view, coming after Baudhāyana and with his text before him, he has not shown any improvement upon Baudhāyana. About the fire-altars, he has discussed different types of *śyenacit,* rectilinear as well as those with curved wings and extended tail and given different arrangements with different types of bricks, but has not gone into the details of other types which he mentions presumably because he has no alternative method of arrangement to suggest. As far as the use of terms and expressions are concerned, there is a remarkable resemblance between Baudhāyana and Āpastamba.

Kātyāyana's treatment is succinct and systematic. He emphasizes the geometry behind the construction of altars and fires and gives a clear exposition of it. He deals with a few altars and *agnis* but refrains from considering the *kāmyacitis* as the latter are discussed separately in a chapter of his *Śrautasūtras.*

The *Mānava-śulbasūtra,* a part of the *Śrautasūtra* by the same author, although following the common tradition of the *śulbakāras,* gives methods and details often very difficult to comprehend. In many cases the details are either lacking or incomplete and can be understood only by reference to Baudhāyana, Āpastamba and Kātyāyana. To us the very arrangement and the treatment of the subject have appeared far from systematic. In our judgement, the work does not measure up to the standard attained by Baudhāyana, Āpastamba and Kātyāyana.

Geometry

Several methods of constructing a square on a given straight line have been given. Rectangles are rectilinear figures of which the two sides are different. For the construction of such rectilinear figures the squared relationship between the diagonal and the two sides has been given at various places in the *śulbasūtras,* which we summarize below:

a) $n^2+(\frac{3}{4}n)^2=(\frac{5}{4}n)^2$	(*Bśl.* 1.5; *Mśl.* 1.11—1.12)
(i) $n=4,\ 4^2+3^2=5^2$	(*Bśl.* 1.13)
(ii) $n=12,\ 12^2+9^2=15^2$	(*Kśl.* 2.5)
(iii) $n=20,\ 20^2+15^2=25^2$	(*Āśl.* 5.3)
(iv) $n=16,\ 16^2+12^2=20^2$	(*Āśl.* 5.3)
b) $n^2+(\frac{5}{12}n)^2=(\frac{13}{12}n)^2$	(*Bśl.* 1.8; *Āśl.* 1.2; *Kśl.* 1.4)
(i) $n=1,\ 1^2+(\frac{5}{12})^2=(\frac{13}{12})^2$	(*Bśl.* 1.8 *Āśl.* 1.2; *Kśl* 1.4-1.5)
(ii) $n=36,\ 36^2+15^2=39^2$	(*Bśl.* 1.13; *Āśl.* 5.4)
(iii) $n=188,\ 188^2+(78\frac{1}{3})^2=(203\frac{2}{3})^2$	(*Āśl.* 6.5)
(iv) $n=6,\ 6^2+(2\frac{1}{2})^2=(6\frac{1}{2})^2$	(*Āśl.* 6.6; *Mśl.* 2.4)

(v) $n=5,\ 5^2+(2\frac{1}{12})^2=(5\frac{5}{12})^2$ (*Āśl.* 6.7)

(vi) $n=10,\ 10^2+(4\frac{1}{6})^2=(10\frac{5}{6})^2$ (*Āśl.* 6.8)

(vii) $n=27,\ 27^2+(11\frac{1}{4})^2=(29\frac{1}{4})^2$ (*Āśl.* 7.3)

(viii) $n=18,\ 18^2+(7\frac{1}{2})^2=(19\frac{1}{2})^2$ (*Āśl.* 7.1—7.2)

(ix) $n=12,\ 12+5^2=13^2$ (*Bśl.* 1.13; *Āśl.* 5.4)

(x) $n=96,\ 96^2+40^2=104^2$ (*Mśl.* 1.4-1.6;)

c) $7^2+24^2=25^2$ (*Bśl.* 1.13)

d) $8^2+15^2=17^2$ (*Bśl.* 1.13; *Āśl.* 5.5)

e) $12^2+35^2=37^2$ (*Bśl.* 1.13; *Āśl.* 5.5)

f) $1^2+3^2=(\sqrt{10})^2$ (*Kśl.* 2.4; *Mśl.* 3.5)

g) $2^2+6^2=(\sqrt{40})^2$ (*Kśl.* 2.5)

h) $1^2+(\sqrt{2})^2+(\sqrt{3})^2$ (*Kśl.* 2.10)

i) $na^2=\left[\frac{(n+1)a}{2}\right]^2-\left[\frac{(n-1)a}{2}\right]^2,$ where a = rational integer (*Kśl.* 6.7)

j) $6^2+(4\frac{1}{2})^2=(7\frac{1}{2})^2$ (*Mśl.* 2.5)

k) $1^2+(\sqrt{10})^2=11$ (*Mśl.* 12.5)

Theorem of Square on the Diagonal of a Square or a Rectangle

The above-mentioned squared relationships are followed or preceded by the general statement that the diagonal of a rectangle produces by itself both (the areas) produced separately by its two sides. This is the so-called theorem known after Pythagoras. A question has often been asked whether such a definition resulted from empirical guess work or was based on a proof of some kind. Such questions are of course to be expected from scholars firmly entrenched in the Euclidean tradition in geometry. As is well known, mathematics, including geometry, in ancient India did not follow the Euclidean tradition, and usually gave the rules, leaving their proofs to be explained by the teachers to the pupils of their respective schools. Several scholars who discussed this issue of proof have shown that such proof is implicit in the very operations with rectilinear figures; we have discussed the matter in detail in our commentaries in connection with the rule and further elaboration here is unnecessary. George Sarton, while considering the question of Hindu influence on Pythagorean derivation of the theorem of squares, referred to Gaston Milhaud's claim that Pythagorean geometry may have been partly inspired by Hindu models. This argument was based on the high antiquity of Baudhāyana and Āpastamba. But Sarton, presumably on the basis of Keith's views on the dates of the *śulbakāras*, pleaded inability to accept such high antiquity and observed: 'It is highly probable that the *śulbasūtras* date from a period posterior to 500 B.C. and pre-Christian. They are probably post-Pythagorean''.[a]

This brings us to the important question of the origin of the theorems and also whether Pythagoras himself was the discoverer of it.

The tradition attributing the theorem to Pythagoras is due to Cicero (*c.* 50 B.C.) Diogenes Laertius (second century A.D.), Athenaeus (*c.* A.D. 300), Heron (third

[a] Sarton, I, 74-75.

century A.D.), and Proclus (*c.*A.D. 460), and therefore started about five centuries after the death of Pythagoras. Junge pointed out that the Greek literature of the first five centuries after Pythagoras contained no mention of the discovery of this or any other important geometrical theorem by the great philosopher and furthermore emphasized uncertainties in the statements of Plutarch and Proclus. Although various attempts have been made to justify the tradition and trace the proof to Pythagoras, no record of proof has come down to us earlier than that given by Euclid (Theorem 47, BK 1). As to the relation $4^2+3^2=5^2$ from which the theorem of rational triangle is derivable, very ancient Egyptian knowledge is attested by the Kahun papyrus of the twelfth dynasty (*c.* 2000 B.C.), but its association with rational triangles does not seem indicated in this or other Egyptian papyrii.[a] As to the antiquity of Pythagorean theorem in China, it is stated, though not proved, in the arithmetical classic *Chou Pei Suan Ching* (third or fourth century B.C.); the numerical relationship 4, 3 and 5 between the sides and the diagonal of a rational rectangle is also given in this text. The old Babylonians of the second millennium B.C. left records on their cuneiform tablets of similar squared relationships indicating practical use of the theorem of squares. No general statement in the form of a theorem is of course found. Neugebauer is of the view that Pythagoras derived his number theorem of the universe as well as the theorem known after his name from such Babylonian cuneiform tablets.[b]

As we have stated, methods have been given for transforming rectilinear figures from squares to rectangles, of transforming squares into circles, of developing isosceles triangle and rhombus from squares and so on. Various geometrical shapes like parallelograms, five-sided rectilinear figures are mentioned in various ways in connection with the construction of bricks with which to cover the sacrificial altars.

Irrational numbers, π , Fractions, Surds

What is of great significance is the treatment of irrational numbers like $\sqrt{2}$ and statement of their accurate values. The manner in which such accurate values were possibly obtained by the *śulbakāras* has been fully discussed in our notes. Neugebauer has shown that these values are identical with those found in certain Babylonian cuneiform texts, given in sexagesimal system. He tried to imply that the Indian value after all represented the Babylonian one expressed only in decimal system or more accurately in fraction. As we have shown, there is certainly no proof of such an assertion and the Indian value is certainly derivable from the methods contained in the *śulbasūtras* themselves.

In connection with the pits for stacking the sacrificial poles in, Baudhāyana has given the ratio of the circumference to the diameter as 3. We have shown from the rules for transforming squares into circles, as given by Baudhāyana, that the *śulbakāras* in all probability knew of more accurate value of π.

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a Heath, (2), I, 352. Sen, Chapter on 'Mathematics', *A Concise History of Science in India,* 148-149,

b Neugebauer, 28-42

The *śulbakāras* were familiar with the use of fractions and manipulated with them in various ways, specially in connection with the construction of bricks for the fire-altars. The terms used by them are significant as well as interesting, of which few examples are given :

caturbhāgona $=1-\frac{1}{4}=\frac{3}{4}$ (*Bśl.* 1.5)
ardhāṣṭama $=7\frac{1}{2}$ (*Bśl.* 5.1, 5.6)
ardhadaśama $=9\frac{1}{2}$ (*Bśl.* 5.1)
ardhanavama $=8\frac{1}{2}$ (*Bśl.* 5.1)
caturtha-saviśeṣārdha$=\frac{1}{2}\,(\frac{1}{4}\sqrt{2})$ (*Āśl.* 19.4)
caturtha-saviśeṣa-saptama$=\frac{1}{7}(\frac{1}{4}\sqrt{2})$ (*Āśl.* 19.7)

In our notes we have explained that elementary knowledge of operating with surds was also possessed by these geometers. It will certainly be not proper to say that the *śulbakāras* dealt with algebra as is known from later Indian mathematicians. But it cannot be denied that germs of algebraic equation are embedded in many of their rules and operations. Such is the case with quadratic equation as also with indeterminate equation of the first degree. As we have amply stressed, these texts were compiled primarily as manuals for the construction of sacrificial fires and altars. Geometry, mensuration, arithmetic, and germs of algebra came out only incidentally. Nevertheless, the gleams we obtain of their knowledge of these subjects can hardly fail to excite our admiration when we remember the time of their compilation.

Source Materials and Plan of Work

In our edition of the *Baudhāyana-śulba,* we have used Thibaut's edition as printed in the *Paṇḍit* and Caland's edition of the *śulba* attached to Baudhāyana's *Śrautasūtra.* Bürk's plan in the break-up of the *sūtras* and their numbering has been followed. This plan appeared to us systematic and logical inasmuch as the breaking up of the *sūtras* and their numbering were generally guided by considerations of self-contained statements. It may also be noted that Caland punctuated the *sūtras* from similar considerations although no numbering was used. We have, however, retained Thibaut's numbering within parenthesis in order that scholars already accustomed to Thibaut's edition may not experience any difficulty. Our edition of the *Āpastamba-śulba* is based on Bürk's *Das Āpastamba-śulbasūtra* and the Mysore edition of the same text. Bürk's arrangement and numbering have been mostly retained; only a few *sūtras* have been regrouped from considerations of self-consistency. In such regroupings also Bürk's number has been given within parenthesis. For the *Kātyāyana-śulba,* we have used the editions by Madana Pāṭhaka, the Kāśī Sanskrit series and the MS. No. G. 6145 of the Asiatic Society, Calcutta. In our edition of the *Mānava-śulba,* Van Gelder's edition of the *śulba* attached to the *Śrautasūtra* and the MS. No. Th. 184 of the National Library, Calcutta have been used and Gelder's arrangement and grouping retained.

As to commentaries, Dvārakānātha's *Śulbamimāṃsā* on Baudhāyana, the commentaries of Kapardisvāmī, Karavindasvāmī and Sundararāja on Āpastamba,

Karkabhāṣya and Mahīdhara's *Śulbasūtravṛtti* on Kātyāyana, and MS. No. 536 of the Bombay Branch of the Asiatic Society, a commentary on the *Mānava-śulba,* have been used. Other manuscripts used by previous editors like Thibaut, Bürk and Van Gelder have been referred to in the foot-notes.

We have given the texts, translations and our own commentaries in separate parts, always referring to the number used in our edition wherever necessary. In writing the commentaries again, the *sūtras,* singly as well as in groups, have been treated as found convenient for purposes of elucidation. In the case of the *Āpastamba-śulba,* a number of chapters dealing with the same topic, e.g. the construction of *śyenacit,* have been dealt with together for the same reason.

PART I

TEXT

BAUDHĀYANA-ŚULBASŪTRA

1.1 *atheme 'gnicayāḥ*/(I.1)* /

1.2 *tesāṃ bhūmeḥ parimāṇavihārānvyākhyāsyāmaḥ* / (I.2) /

1.3 *athāṅgulapramānaṃ* (I.3) *caturdaśāṇavaḥ* (I.4) *catustriṃśattilāḥ pṛthusaṃśliṣṭā ityaparam* / (I.5) / *daśāṅgulaṃ kṣudrapadam* / (I.6) / *dvādaśa prādeśaḥ*[1] / (I.7) / *pṛthottarayuge trayodaśike* / (I.8) *padaṃ pañcadaśa* / I.9) / *aṣṭāśītiśatamīṣā* (I.10) *catuḥśatamakṣaḥ* / (I.11) / *ṣaḍaśītiryugam* / (I.12)/ *dvātriṃśajjānuḥ* /(I.13)/ *ṣaṭtriṃśacchamyābāhū* / (I.14) / *dvipadaḥ prakramaḥ*/ (I.15) / *dvau prādeśāvaratniḥ* / (I.16) / *athāpyudāharanti* (I.17) *pade yuge prakrame 'ratnāviyati śamyāyāṃ*[2] *ca mānārtheṣu yāthākāmīti* / (I.18) / *pañcāratniḥ puruṣo* (I.19) *vyāmaśca*[3] / (I.20) / *caturaratnirvyāyāmaḥ*/(I.20) /

1.4 *caturaśraṃ*[4] *cikīrṣanyāvaccikīrṣettāvatīṃ rajjumubhayataḥ pāśāṃ kṛtvā madhye lakṣaṇaṃ karoti* / *lekhāmālikhya* (I.22) *tasyā madhye śaṅkuṃ nihanyāt* / *tasminpāśau pratimucya*[5] *lakṣaṇena maṇḍalaṃ parilikhet* / *viṣkambhāntayoḥ śaṅkū nihanyāt* / (I.23) / *pūrvasminpāśaṃ pratimucya pāśena maṇḍalaṃ parilikhet*/(I.24) / *evamaparasmiṃste yatra sameyātāṃ tena dvitīyaṃ viṣkambhamāyacchet* /(I.25) / *viṣkambhāntayoḥ śaṅkū nihanyāt* / (I.26) / *pūrvasminpāśau pratimucya lakṣaṇena maṇḍalaṃ parilikhet*/(I.27) / *evaṃ dakṣiṇata evaṃ paścādevamuttaratasteṣāṃ ye 'ntyāḥ saṃsargāstaccaturaśraṃ saṃpadyate* / (I.28) /

1.5 *athāparaṃ* / (I.29) / *pramāṇāddviguṇāṃ rajjumubhayataḥ pāśāṃ kṛtvā madhye lakṣaṇaṃ karoti* / (I.30) / *sa prācyarthaḥ* / (I.31) / *aparasminnardhe caturbhāgone lakṣaṇaṃ karoti* /(I.32)/ *tannyañcanam*[6] /(I.33)/ *ardhe'ṃsārthaṃ*/ (I.34) / *pṛṣṭhyāntayoḥ pāśau pratimucya nyañcanena dakṣiṇāpāyamyārdhena śroṇyaṃsānnirharet* / (I.35) /

1.6 *dīrghacaturaśraṃ cikīrṣanyāvaccikīrṣettāvatyāṃ bhūmyāṃ*[7] *dvau śaṅkū nihanyāt* / (I.36) / *dvau dvāvekaikamabhitaḥ*[8] *samau* / (I.37) / *yāvatī tiryaṅmānī*

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* The numbering within parenthesis refers to Thibaut's edition as printed in the *Pandit*.

[1] *dādaśāṅgulaṃ prādeśaṃ*, M.

[2] *śāmyāyāṃ*, C.

[3] *ca* in T, but not in other Mss used by C.

[4] C retains *-śra* as used throughout B,U,M; *-sra* throughout H, T.

[5] *pramucya* in B,M,H.

[6] *nyañchanam* in T.

[7] Throughout H,U,B,M ; *bhūmau* in T.

[8] *-vekamabhitaḥ* in B, *-vekaivamabhitaḥ* in H.

tāvatīṃ rajjumubhayataḥ pāśāṃ kṛtvā madhye lakṣaṇaṃ karoti / *pūrveṣāmantyayoḥ pāśau pratimucya lakṣaṇena dakṣiṇāpāyamya lakṣaṇe lakṣaṇaṃ karoti*/ (I.38)/ *madhyame pāśau pratimucya lakṣaṇasyopariṣṭāddakṣiṇāpāyamya lakṣaṇe śaṅkuṃ nihanyāt*/(I.39)/*so'ṃsa etenottaro 'ṃso vyākhyātastathā śroṇī*/(I.40)/

1.7 *yatra purastādaṃhīyasīṃ minuyāttatra tadardhe lakṣaṇaṃ karoti* /(I.41)/

1.8 *athāparaṃ*/ *pramāṇādadhyardhāṃ rajjumubhayataḥ pāśāṃ kṛtvāparasmiṃstṛtīye ṣaḍbhāgone lakṣaṇaṃ karoti*/(I.42)/*tannyañcanam*/(I.43)/ *iṣṭe'ṃsārtham*[9]/ *pṛṣṭhyāntayoḥ pāśau pratimucya nyañcanena dakṣiṇāpāyamyeṣṭena śroṇyaṃsānnirharet*/(I.44)/

1.9 *samacaturaśrasyākṣṇayārajjurdvistāvatīṃ bhūmiṃ karoti*/(I.45)/

1.10 *pramāṇaṃ tiryagdvikaraṇyāyāmastasyākṣṇayārajjustrikaraṇī*/(I.46)/

1.11 *tṛtīyakaraṇyetena vyākhyātā* / *navamastu*[10] *bhūmerbhāgo bhavatīti*[11]/ (I.47)/

1.12 *dīrghacaturaśrasyākṣṇayārajjuḥ pārśvamānī*[12] *tiryaṅmānī ca yatpṛthagbhūte kurutastadubhayaṃ karoti*/(I.48)/

1.13 *tāsāṃ*[13] *trikacatuskayordvādaśikapañcikayoḥ*[14] *pañcadaśikāṣṭikayoḥ*[15] *saptikacaturviṃśikayor*[16]*dvādaśikapañcatriṃśikayoḥ pañcadaśikaṣaṭtriṃśikayorityetāsūpalabdhiḥ*/(I.49)/

2

2.1 *nānācaturaśre samasyankanīyasaḥ karaṇyā varṣīyaso vṛdhram*[17]*ullikhet*/ *vṛdhrasyākṣṇayārajjuḥ samastayoḥ pārśvamānī bhavati* / (I.50) /

2.2 *caturaśrāccaturaśraṃ nirjihīrṣanyāvannirjihīrṣettasya karaṇyā varṣīyaso vṛdhramullikhet* / *vṛdhrasya pārśvamānīmakṣṇayetaratpārśvamupasaṃharet* / *sā yatra nipatettadapacchindyāt* / *chinnayā nirastam* / (I.51) /

2.3 *samacaturaśraṃ dīrghacaturaśraṃ cikīrṣaṃstadakṣṇayāpacchidya bhāgaṃ dvedhā vibhajya pārśvayorupadadhyād*[18]*yathāyogam* / (I.52) /

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[9] *-ṣṭena sārdhaṃ*, M.

[10] Before *nava*-M. ins *vibhāgastu tāsāṃ*.

[11] *bhavati*, M.

[12] *ca* ins M.

[13] Found in all copies except in T.

[14] M. omits *dvādaśi ... kayoh*.

[15] *pañcikaṣaṣṭikayoḥ*, M.

[16] *-viṃśati*—for *-viṃśi*, M.

[17] *vṛddha for vṛdhra* in Mss. C; *vṛdhra* in T.

[18] *rupasaṃdadhyāt*, M, U, B.

2.4 *api vai*[19]*tasmiṃścaturaśraṃ samasya tasya karaṇyāpacchidya*[20]*yadatiśiṣyate taditaratropadadhyāt* / I.53) /

2.5 *dīrghacaturaśraṃ samacaturaśraṃ cikīrṣaṃstiryaṅmānīṃ karaṇīṃ kṛtvā śeṣaṃ dvedhā vibhajya pārśvayo*[21]*rupadadhyāt*[22] / *khaṇḍamāvāpena tatsaṃpūrayet* / *tasya nirhāra*[23] *uktaḥ* / (I.54) /

2.6 *caturaśramekato' ṇimaccikīrṣannaṇimataḥ karaṇīṃ tiryaṅmānīṃ kṛtvā śeṣamakṣṇayā vibhajya viparyasyetaratropadadhyāt* / (I.55) /

2.7 *caturaśraṃ praugaṃ cikīrṣanyāvaccikīrṣeddvistāvatīṃ bhūmiṃ samacaturaśrāṃ kṛtvā pūrvasyāḥ karaṇyāḥ madhye śaṅkuṃ nihanyāt* / *tasminpāśau pratimucya dakṣiṇottarayoḥ śroṇyornipātayet* / *bahispandyamapacchindyāt* / I.56) /

2.8 *caturaśramubhayataḥ praugaṃ cikīrṣanyāvaccikīrṣeddvistāvatīṃ bhūmiṃ dīrghacaturaśrāṃ kṛtvā pūrvasyāḥ karaṇyāḥ madhye śaṅkuṃ nihanyāt* / *tasminpāśau pratimucya dakṣiṇottarayormadhyadeśayornipātayet* / *bahiḥs*[24]*pandyamapacchindyāt* / *etenāparaṃ praugaṃ vyākhyātam* / (I.57) /

2.9 *caturaśraṃ maṇḍalaṃ cikīrṣannakṣṇayārdhaṃ madhyātprācīmabhyāpātayet*[25] / *yadatiśiṣyate tasya saha tṛtīyena maṇḍalaṃ parilikhet* / (I.58) /

2.10 *maṇḍalaṃ caturaśraṃ cikīrṣanviṣkambhamaṣṭau bhāgānkṛtvā bhāgamekonatriṃśadhā*[26] *vibhajyāṣṭāviṃśatibhāgānuddharet* / *bhāgasya ca ṣaṣṭhamaṣṭamabhāgonam* / (I.59) /

2.11 *api vā pañcadaśabhāgānkṛtvā dvāvuddharet* / *saiṣānityā*[27] *caturaśrakaraṇī* / (I.60) /

2.12 *pramāṇaṃ tṛtīyena vardhayettacca*[28] *caturthenātmacatustriṃśonena* / (I.61) / *saviśeṣaḥ* / (I.62) /

3

3.1 *athāgnyādheyike vihāre*[29] (I.63) *gārhapatyādāhavanīyasyāyatanam* /

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[19] *api vaita-* in C; *api caita-* in T.
[20] *-chindyād* in M; also in T.
[21] *viparyasyetaratra* in T for *pārśvayoḥ*.
[22] *upasaṃdadhyāt* in B, H, U.
[23] *nirhāsa*, B, U; see also *ZDMG*, **55**, 579.
[24] *bahispandya*, C.
[25] *-bhyāyātaye-*, B, M.
[26] *-viṃśadhā*, H, M.
[27] *eṣā* instead of *saiṣā* in H, B & T.
[28] *ca* in T, not in C.
[29] *vihāraḥ* in T.

(I.64) / *vijñāyate 'ṣṭaṣu prakrameṣu brāhmaṇo'gnimādadhītaikādaśasu rājanyo dvādaśasu vaiśya iti* / (I.65-66) /

3.2 *āyāmatṛtīyena trīṇi caturaśrāṇyanūcīnāni kārayet / aparasyottarasyāṃ*[30] *śroṇyāṃ gārhapatyaḥ / tasyaiva dakṣiṇe 'ṃse 'nvāhāryapacanaḥ pūrvasyottare 'ṃsa āhavanīyaḥ* / (I.67) /

3.3 *api vā gārhapatyāhavanīyayorantarālaṃ pañcadhā ṣoḍhā vā saṃbhujya ṣaṣṭhaṃ saptamaṃ vā bhāgamāgantukamupasamasya*[31] *samaṃ traidhaṃ vibhajya pūrvasmādantād*[32] *dvayorbhāgayorlakṣaṇaṃ karoti / gārhapatyāhavanīyayorantau niyamya lakṣaṇena dakṣiṇāpāyamya lakṣaṇe śankuṃ nihanti / taddakṣiṇāgnerāyatanaṃ bhavati* / (I.68) /

3.4 *api vā pramāṇaṃ pañcamena vardhayet / tatsarvaṃ pañcadhā saṃbhujyāparasmādantāddvayorbhāgayorlakṣaṇaṃ karoti / pṛṣṭhyāntayoḥ pāśau pratimucya lakṣaṇena dakṣiṇāpāyamya lakṣaṇe śaṅkuṃ nihanti / taddakṣiṇāgnerāyatanaṃ bhavati* / (I.69) /

3.5 *viparyastaitenotkaro vyākhyātaḥ* / (I.70) /

3.6 *aparenāhavanīyaṃ yajamānamātrī bhavatīti dārśapaurṇamāsikāyā vedervijñāyate* / (I.71) /

3.7 *tasyāstribhāgonaṃ paścāttiraścī / tasyā evārdhaṃ purastāttiraścī*[33] / *evaṃ dīrghacaturaśramekato 'ṇimadvihṛtya sraktiṣu śaṅkūnnihanyāt* / (I.72) /

3.8 *yāvatī pārśvamānī dvirabhyastā*[34] *tāvatīṃ rajjumubhayataḥ pāśāṃ kṛtvā madhye lakṣaṇaṃ karoti / dakṣiṇayoḥ pārśvayoḥ*[35] *pāśau pratimucya lakṣaṇena dakṣiṇāpāyamya lakṣaṇe śaṅkuṃ nihanyāt / tasminpāśau pratimucya lakṣaṇena dakṣiṇaṃ pārśvaṃ parilikhet* / (I.73) / *etenottaraṃ pārśvaṃ vyākhyātam* / (I.74) / *pūrvaṃ pārśvaṃ tayā dvirabhyastayā parilikhet / evamaparam*/ (I.75)

3.9 *daśapadā paścāttiraścī dvādaśapadā prācyaṣṭāpadā purastāttiraścīti pāśubandhikāyā vedervijñāyate / mānayogastasyā vyākhyātaḥ* / (I.76) / *rathasaṃmitetyekeṣām* / (I.77) / *virāṭsaṃpannetyekeṣām* / (I.78) /

3.10 *śamyāmātrī catuḥsraktirbhavatītyuttaravedervijñāyate* / (I.79) / *samacaturaśrāviśeṣāt* / (I.80) /

3.11 *vitṛtīyā vedirbhavatīti paitṛkyā*[36] *vedervijñāyate* / (I.81 / *mahāvedes-*

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[30] *-daparasyottarasyottarasyām*, B, M.

[31] *-gaṃtumupasamasya*, H, U.

[32] Thibaut has justified the term *antāt* although *antyāt* has been used in all Mss.

[33] *-ttiraścī yāvad*, M.

[34] *abhyastā* missing in B.

[35] Occurs in H, M, U; omitted in B, T.

[36] *paitṛyajñikāyā*, B, U originally.

tṛtīyena samacaturaśrakṛtāyāstṛtīyakaraṇī[37] *bhavatīti*[38] / *navamastu bhūmer-bhāgo bhavati*[39] / (I.82) / *yajamānamātrī catuḥsraktirbhavatītyekeṣām* / (I.83)/ *dikṣu sraktayo bhavanti* / (I.84 /

3.12 *veditṛtīye yajeteti sautrāmaṇikīṃ vedimabhyupadiśanti* / (I.85) / *mahāvedestṛtīyena samacaturaśrakṛtāyā aṣṭādaśapadā pārśvamānī bhavati* / (I.86) / *tasyai dīrghakaraṇyāmekato 'ṇimatkaraṇyāṃ ca yathākāmīti* / (I.87) /

4

4.1 *prāgvaṃśaḥ ṣoḍaśaprakramāyāmo dvādaśavyāso*[40] *'pi vā dvādaśapra-kramāyāmo daśavyāsaḥ* / (I.88) /

4.2 *tasya madhye dvādaśiko vihāraḥ* / (I.89 /

4.3 *triṃśatpadāni prakramā vā paścāttiraścī bhavati ṣaṭtriṃśatprācī caturviṃśatiḥ purastāttiraścīti mahāvedervijñāyate*/ *mānayogastasyā vyākhyātaḥ*/ (I.90) / *āhavanīyātṣaṭ prakramānmahāvediḥ* / (I.91) /

4.4 *tata ekasminsadaḥ* / (I.92) / *taddaśakam* / (I.93) / *udak saptaviṃśa-tyaratnayaḥ* / (I.94) / *aṣṭādaśetyekeṣām* / (I.95) /

4.5 *tataścaturṣu havirdhānam* / *taddaśakaṃ dvādaśakaṃ vā*[41] *mānayoga-stayorvyākhyātaḥ* / (I.96) /

4.6 *yūpāvaṭīyācchaṅkorardhaprakramamavaśiṣyottaravediṃ vimimīte* / (I.97) / *daśapadottaravedirbhavatīti some vijñāyate* / *mānayogastasyā vyākhyātaḥ* / (I.98) /

4.7 *cātvālaḥ śamyāmātro 'parimito vā* / (I.99) /

4.8 *athoparavāḥ prādeśamukhāḥ prādeśāntarālāḥ* / (I.100) / *aratnimātraṃ samacaturaśraṃ vihṛtya sraktiṣu śaṅkūnnihanyāt* / *ardhaprādeśenārdhaprā-deśenaikaikaṃ maṇḍalaṃ*[42] *parilikhet* / (I.101) /

4.9 *sadasaḥ*[43] *pūrvārdhāddviprakramamavaśiṣya dhiṣṇyānāṃ*[44] *dviprādeśo viṣkambhastathāntarālāḥ* / (I.102) /

4.10 *āgnīdhrāgārasya*[45] *pārśvamānī pañcāratniḥ* / (I.103) /

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[37] *-kṛtāyāḥ karaṇī tṛtīyakaraṇī* B, U; see also T's explanation with reference to commentaries.

[38] *bhavati*, M, U; *bhavatī*, H.

[39] *bhavatīti*, M.

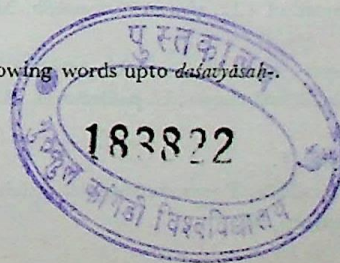
[40] *dvādaśapadavyāsa-*, M which omits the following words upto *daśavyāsaḥ-*.

[41] After *vā*, T has *samacaturasraṃ*.

[42] *parimaṇḍalam*, M, U.

[43] *-tsadaḥ*, H.

[44] Not *dhiṣṇiyā-*, the Mss.

[45] *āgnīdhrīyā*, T.

4.11 *etena mārjālīyo vyākhyātaḥ* / (I.104) / *tasyodīcīṃ dvāraṃ kurvanti* / (I.105) /

4.12 *rathākṣāntarālā yūpāvaṭā bhavantītyekādaśinyāṃ vijñāyate* / (I.106) / *tasyā*[46] *daśānāṃ ca rathākṣāṇāmekādaśānāṃ ca padānāmaṣṭāṅgulasya ca caturviṃśaṃ bhāgamādadīta* / *sa prakramaḥ syāt* / *tena vediṃ vimimīte* / (I.107) /

4.13 *athāśvamedhe*[47] *viṃśatyāśca rathākṣāṇāmekaviṃśatyāśca padānāmaṣṭāṅgulasya ca caturviṃśaṃ bhāgamādadīta* / *sa prakramaḥ syāt* / *tena vediṃ vimimīte*[48] / (I.108) /

4.14 *atha prācyekādaśinyāṃ*[49] *yūpārthaṃ vedeḥ pūrvārdhātpadārdhavyāsamapacchidya*[50] *tatpurastātprāñcaṃ*[51] *dadhyāt* / (I.109) / *nātrāṣṭāṅgulaṃ vidyate* / (I.110) / *na vyatiṣaṅgaḥ* / (I.111) /

4.15 *yūpāvaṭāḥ padaviṣkambhāstripadapariṇāhāni yūpoparāṇīti* / (I.112-3)

5

5.1 *ardhāṣṭamāḥ puruṣāḥ*[52] *prathamo 'gniḥ* / (II.1) / *ardhanavamā dvitīyaḥ* / (II.2) / *ardhadaśamāstṛtīyaḥ* / (II.3) / *evamuttarottaro vidhābhyāsa ekaśatavidhāt*[53] / (II.4) / *tadetatsaptavidhaprabhṛtyekaśatavidhāntam* / (II.5) /

5.2 *ata ūrdhvamekaśatavidhāneva pratyādadīta* / (II.6) / *anagnikānvā yajñakratūnāharet* / (II.7) / *anyatrāśvamedhāt* / (II.8 /

5.3 *aśvamedhamaprāptaṃ cedāharedata ūrdhvaṃ vidhāmabhyasyennetaradādriyeta*[54] / (II.9) /

5.4 *atītaṃ cedāharedāhṛtya kṛtāntādeva pratyādadīta* / (II.10) /

5.5 *kathamu khalu vidhāmabhyasyet* / (II.11) /

5.6 *yadanyatprakṛtestatpañcadaśa bhāgānkṛtvā vidhāyāṃ vidhāyāṃ dvau dvau bhāgau samasyet* / *tābhirardhāṣṭamābhiragniṃ cinuyāt* / (II.12) /

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[46] *tasyai*, U.

[47] With the last word of 4.12. *vimimītāthāśvamedhe*, M.

[48] *-mitātha*, M.

[49] *prācye-*, M; *prācyai-*, other Mss; *-nyā*, U; *prāṃcyai*, T.

[50] Thus M; *pūrvārdhātpadārthavyā-*, U. *padārdhavyā-*, B, *pūrvārdhāsadārdhanyā*. H

[51] *-prācyāṃ*, M.

[52] *ardhāṣṭamapuruṣāḥ*, T.

[53] C retains *ekādaśavidhāt-*; T uses *ekaśatavidhāt* which is meaningful.

[54] *-bhasyedanyataradādri-*, M.

5.7 *ūrdhvapramāṇābhyāsaṃ jānoḥ pañcamasya caturviṃśenaike*[55] *samāmananti* / (II.13) /

5.8 *atha haika ekavidhaprabhṛtīnapakṣapucchāṃścinvate* / (II.14) /

5.9 *tannopapadyate pūrvottaravirodhāt* / (II.15) /

5.10 *atha haikeṣāṃ brāhmaṇaṃ bhavati śyenacidagnīnāṃ pūrvā tatiriti* / (II.16) /

5.11 *athāpareṣāṃ*[56] *na jyāyāṃsaṃ citvā kanīyāṃsaṃ cinvīteti* / (II.17-18) /

5.12 *athāsmākaṃ*[57] / (II.19) / *pakṣī bhavati* / *na hyapakṣaḥ patitumarhati* / *aratninā pakṣau drāghīyāṃsau bhavataḥ* / *tasmātpakṣapravayāṃsi vayāṃsi* / *vyāmamātrau pakṣau ca puccham ca bhavatīti* / (II.20) /

5.13 *nāpakṣapucchaḥ śyeno vidyate* / *na cāsaptavidhasya pakṣapucchāni vidyante* / *na ca saptavidhaṃ citvaikavidhaprasaṅgaḥ* / *tasmātsaptavidha eva prathamo 'gniḥ* / (II.21) /

5.14 *bhedānvarjayet* / (II.22) / *adharottarayoḥ pārśvasaṃdhānaṃ bhedā ityupadiśanti* / (II.23) / *tadagnyanteṣu na vidyate*[58] *na sraktipārśvayoḥ* / (II.24-25) /

5.15 *sāhasraṃ cinvīta prathamaṃ cinvāna iti*[59] / (II.26) /

5.16 *pañcamāyāṃ vā citau saṃkhyāṃ pūrayet* / (II.27) /

5.17 *dviśatāśceccikīrṣetpañcacoḍābhirnākasadaḥ*[60] *samānasaṃkhyaṃ pratīyāt* / (II.28) /

6

6.1 *paśudharmo*[61] *ha vā agniḥ* / *yathā ha vai paśordakṣiṇeṣāmasthnāṃ yaddakṣiṇaṃ pārśvaṃ taduttareṣāmuttaraṃ yaduttareṣāṃ dakṣiṇaṃ taddakṣiṇeṣāmuttaraṃ yadavāk*[62] *cordhvaṃ*[62] *ca*[62] *tatsamānamevamiṣṭakānāṃ rūpāṇyupadadhyāt* / (II.29) /

6.2 *yā dakṣiṇāvṛto lekhāstā dakṣiṇata upadadhyāt* (II.30) *savyāvṛta uttarataḥ* / (II.31) / *ṛjulekhāḥ paścācca*[63] *purastācca bhavanti* / (II. 32) / *tryālikhitā*

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[55] *-senaivaike*, T.

[56] *-thāparam*, M.

[57] *brāhmaṇaṃ* ins U on the margin; for the *brāhmaṇa* see TS. V.2.5.1.

[58] *vidyaṃte*, U.

[59] See TS. V. 6.8.2.

[60] *śatāṃśce*, U; *-coḍānākasadaḥ*, M.

[61] *-dharmā*, B, M, U.

[62] *yadvāṃcaṃ*, M; *yadarvāk co*, B; *paścātpurastācca*, T.

[63] Thus H, M, U; *paścāt*, B.

madhye / (II.33) / *atha yā viśayasthā*[64] *yathā ha vai paśoḥ pṛṣṭhavaṃśo naivaikasminpārśve vyatirekeṇa vartate naivāparasminnevaṃ tāsāmupadhānaṃ pratīyāt* / (II.34) /

6.3 *athāpi brāhmaṇaṃ*[65] *bhavati* / (II.35) / *prajāpatirvā atharvāgnireva dadhyaññātharvaṇastasyeṣṭakā asthānīti* / (II.36) /

6.4 *tasmād*[66]*bahistanvaṃ ceccinuyāttanvopaplavamadhyairātmopaplava*[67]*madhyāt saṃdadhyāt* / (II.37) /

6.5 *prāñcamenaṃ cinuta iti vijñāyate* / (II.38) /

6.6 *amṛnmayībhiraniṣṭakābhirna*[68] *saṃkhyāṃ pūrayet* / (II.39) /

6.7 *iṣṭakacidvā*[69] *anyo 'gniḥ paśucidanya ityetasmādbrāhmaṇāt* / (II.40) /

6.8 *paśurvā eṣa yadagniryoniḥ khalu vā eṣā paśorvikriyate*[70]*yatprācīnamaiṣṭakādyajuḥ kriyata*[71] *iti ca*[72] / (II.41) /

6.9 *lokabādhīni*[73] *dravyāṇyavaṭeṣūpadadhyāt* / (II.42) /

6.10 *maṇḍalamṛṣabhaṃ vikarṇīmitīṣṭakāsu lakṣmāṇi pratīyāt* / (II.43) /

6.11 *iṣṭakāmantrayoriṣṭakāvyatireke lokaṃpṛṇāḥ saṃpadyante parimāṇābhāvāt* / (II.44) /

6.12 *atītāneva veṣṭa*[74]*kāgaṇānatropadadhyāt* / (II.45) /

6.13 *pañca lokaṃpṛṇāḥ* / (II.46) /

6.14 *mantravyatireke 'ktāḥ śarkarāḥ saṃdhiṣūpadadhyāt* / (II.47) /

6.15 *prācīrupadadhāti pratīcīrupadadhātīti gaṇeṣu rītivādaḥ* / (II.48) /

6.16 *prācīmupadadhāti pratīcīmupadadhātīti karturmukhavādaḥ* / (II.49) /

6.17 *purastādanyāḥ pratīcīrupadadhāti paścādanyāḥ prācīrityapavargaḥ*[75] / (II.50) /

6.18 *caturaśrāsvevaitadupapadyate* / (II.51) /

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[64] Thus, T.; *viṣaya-*, H, M, B, U.

[65] TS. V. 6.6.3.

[66] Not in T.

[67] Some of the Mss have (as *Lāṭyāyana* (1.5.7.) *upablaya* or *blaya*.

[68] *-yobhiriṣṭakābhi-*, M, B.

[69] TS. I. 5.8.2.

[70] *vikriyata iti*, T.

[71] *-yat iti*, B, U; but we have one single citation in TS. V. 2.10.1.

[72] H omits.

[73] *ba* with H, U, B, M; *va* with T.

[74] Thus, B, U; *-tītāneva-*, M,; H is incomplete; T reads: *atītāneveṣṭakāgaṇānetadatro*.

[75] *-vargavādaḥ* in T.

7

7.1 *na khaṇḍāmupadadhyāt* / (II.52) / *na bhinnāmupadadhyāt* / (II.53) / *na kṛṣṇāmupadadhyāt* / (II.55)[76] / *na jīrṇāmupadadhyāt* / (II.54) / *na lakṣmaṇām*[77]*upadadhyāt* / (II.56)/ *na svayamātṛṇṇāṃ svayaṃcitāvupadadhyāt*/ (II.57) /

7.2 *ūrdhvapramāṇamiṣṭakānāṃ jānoḥ pañcamena kārayet* / (II.58) / *ardhena nākasadāṃ pañcacoḍānāṃ ca* / (II.59) /

7.3 *yacchoṣapākābhyāṃ pratihraseta*[78] *purīṣeṇa tatsaṃpūrayet purīṣasyāniyataparimāṇatvāt* / (II.60) /

7.4 *vyāyāmamātrī bhavatīti gārhapatyacitervijñāyate* / (II.61) /

7.5 *caturaśretyekeṣāṃ* / (II.62) / *parimaṇḍaletyekeṣām* / (II.63) /

7.6 *caturaśraṃ saptadhā vibhajya tiraścīṃ tredhā vibhajet* / (II.64) / *aparasminprastāra udīcīrupadadhāti* / (II.65) /

7.7 *samacaturaśrāścedupadadhyād*-(II.66) -*vyāyāmaṣaṣṭheneṣṭakāḥ kārayeccaturthena tṛtīyeneti* / (II.66-67) / *tāsāṃ nava prathamā dvādaśa dvitīyā iti pūrvasminprastāra upadadhāti* / (II.68) / *pañca tṛtīyāḥ ṣoḍaśa prathamā ityaparasmin* / (II.69) /

7.8 *parimaṇḍalāyāṃ yāvatsaṃbhavettāvatsamacaturaśraṃ kṛtvā tannavadhā vibhajet* (II.70) *pradhīṃstridhā tridheti* / (II.71)/ *aparaṃ prastāraṃ*[79] *tathopadadhyādyathā pradhyanīkeṣu sraktayo bhavanti* / (II.72) /

7.9 *dhiṣṇyā ekacitīkāścaturaśrāḥ parimaṇḍalā vā* / (II.73) /

7.10 *teṣāmāgnīdhrīyaṃ navadhā vibhajyaikasyāḥ sthāne' śmānamupadadhyāt*/ (II.74) /

7.11 *atha hoturdhiṣṇyaṃ*[80] *navadhā vibhajya pūrvāṃstribhāgānekaikaṃ dvedhā vibhajet* / (II.75) /

7.12 *athetarānnavadhā navadhā vibhajya madhyamapūrvau dvau*[81] *bhāgau samasyet* / (II.76) /

7.13 *atha mārjālīyaṃ tredhā vibhajya pūrvāparau bhāgau pañcadhā vibhajet* / (II.77) /

7.14 *ukhyabhasmanā saṃsṛjyeṣṭakāḥ kārayediti* / (II.78) /

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[76] In T. *na jīrṇām* precede *na kṛṣṇām-*

[77] Thus H., *lakṣmāmu-* M. U; *lakṣṇamu-* T.

[78] Thus U and T; *-set* H. M. B.

[79] *-parasminprastāre*, M.B.

[80] *dhiṣṇiyaṃ*, H. M.

[81] *dvau dvau*, M.

7.15 *saṃvatsarabhṛta evaitadupapadyate na rātribhṛtaḥ* / (II.79) /

7.16 *evamasya mantravatī citiklṛptiḥ* / (II.80) /

7.17 *chandaścitaṃ triṣāhasrasya parastāccinvīta* (II.81) *kāmavivekāt tasya rūpaṃśyenākṛtirbhavatīti*[82] / (II.83) /

8

8.1 *atha vai bhavati śyenacitaṃ cinvīta suvargakāma iti* / (III.1) /

8.2 *ākṛtidvaividhyam* / (III.2) / *caturāśrātmā*[83] (III.3) *śyenākṛtiśca* / (III.4) /

8.3 *vijñāyate ubhayaṃ brāhmaṇam*[84] / (III.5-6) /

8.4 *pañca dakṣiṇāyāṃ śroṇyāmupadadhāti pañcottarasyām* / *basto vaya iti dakṣiṇe'ṃsa upadadhāti* / *vṛṣṇirvaya ityuttare* / *vyāghro vaya iti dakṣiṇe pakṣa upadadhāti* / *siṃho vaya ityuttare*[85] *puruṣo vaya iti madhya iti ca* / (III.7) /

8.5 *athāparaṃ* / *vayasāṃ vā eṣa pratimayā cīyate yadagniriti* / (III.8) / *utpatatāṃ chāyayetyarthaḥ* / (III.9) /

8.6 *samacaturaśrābhiragniṃ cinute*[86] *daivyasya ca mānuṣasya ca vyāvṛttyā iti maitrāyaṇīyabrāhmaṇaṃ*[87] *bhavati* / (III.10) /

8.7 *tasyeṣṭakāḥ kārayet puruṣasya*[88] *caturthena pañcamena ṣaṣṭhena daśameneti* / (III.11) /

8.8 *athāgniṃ vimimīte* / (III.12) /

8.9 *yāvānpuruṣa ūrdhvabāhustāvadantarāle veṇośchidre*[89] *karoti* / (III.13) / *madhye tṛtīyaṃ* / (III.14) / *yadamutra spandyayā karoti tadiha veṇunā karoti* / (III.15) /

8.10 *tasyātmā* (III.16) *samacaturaśraścatvāraḥ puruṣāḥ* / (III.17) / *pakṣaḥ samacaturaśraḥ puruṣaḥ* / (III.18) / *sa tu dakṣiṇato'ratninā drāghīyān* / (III.19) / *etenottaraḥ pakṣo vyākhyātaḥ* / (III. 20) / *pucchaḥ samacaturaśraḥ*

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[82] T. and H. add *prakṛtitvāt*.

[83] *caturasrā*-in T.

[84] The first in TS. V. 3.1.5; the second in TS. V. 5.3.2.

[85] U. and *Mahāgnisarvasya* ins. *pakṣayoreva vīryaṃ dadhāti*.

[86] H. U. B. M.; *cinvīta* in T.

[87] Passage not traceable.

[88] Omitted in T.

[89] Thus M; *veṇoh chidre*, M. U.; *veṇochidre*, B. and T.

puruṣaḥ / (III.21) / *tamavastāt*[90]*prādeśena vardhayet* / (III.22) / *evaṃ sāratni prādeśā saptavidhaḥ saṃpadyataḥ*[91] / (III.23) /

8.11 *upadhāne pakṣāgrāduttarataḥ puruṣatṛtīyavelāyāṃ* (III.24) *catasraḥ pañcamyastāsāmabhito dve dve pādeṣṭake* / (III.25) / *tato'ṣṭau caturthyaḥ*/ (III.26) / *pakṣaśeṣaṃ ṣaḍbhāgīyābhiḥ pracchādayet* / (III.27) / *etenottaraḥ pakṣo vyākhyātaḥ* / (III.28) /

8.12 *pūrvāparayoḥ pucchapārśvayoścaturbhāgīyā upadadhyāt* / (III.29) / *dakṣiṇottarayoḥ pādeṣṭakāḥ* / (III.30) / *śeṣamagniṃ pañcamabhāgīyābhiḥ pracchādayet* / (III.31) /

8.13 *eṣa dviśataḥ prastāraḥ* / (III.32) /

8.14 *aparasminprastāre* (III.33) *pakṣāgrāduttarato' rdhavyāyāmavelāyāṃ tisrastisraḥ ṣaṣṭhyo dve dve dvipade iti viparyāsamupadadhyāt* / (III.34) / *tathottare*[92] / (III.35) /

8.15 *dakṣiṇasyāṃ śroṇyāṃ nava ṣaṣṭhyaścaturaśrakṛtāḥ* / (III.36) / *tathottarasyām* / (III.37) /

8.16 *nava nava ṣaṣṭhyo dve dve dipade iti dakṣiṇādaṃsāduttarādaṃsādviparyāsamupadadhyāt* / (III.38) /

8.17 *śeṣamagniṃ pañcamabhāgīyābhiḥ pracchādayet* / (III.39) /

8.18 *eṣa dviśataḥ prastāro vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (III.40) /

9

9.1 *athāparaḥ* / (III.41) /

9.2 *puruṣasya pañcamyaḥ* / (III.42) / *tā evaikato' dhyardhāḥ* / (III.43) / *tāsāmardhyāḥ pādyāśca* / (III.44-45) /

9.3 *upadhāne* / (III.46) / *pūrvāparayoḥ pakṣapārśvayorardheṣṭakā udīcīrupadadhyāt* / (III.47) / *tathottare* / (III.48) /

9.4 *dakṣiṇottarayoḥ pucchapārśva*[93]*yoścatasraścatasro' dhyardhā udīcīḥ* / (III.49) / *pucchasyāvastāccatasro' rdheṣṭakā udīcīḥ* / (III.50) / *tāsāmabhito dve pādeṣṭake* / (III.51) / *jaghanena pucchāpyayor*[94]*ekaikāmardheṣṭakāṃ prācīm* / (III.52) /

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[90] *adhastāt* instead of *avastāt*, M.

[91] *saṃpadyate* in T.

[92] *-dadhyādevamuttare*, B.

[93] *pucchapakṣayo-*, B.

[94] *pucchasyā-*, U– *pucchapārśvayo-*, M.

9.5 *seṣamagniṃ pañcamabhāgīyābhiḥ pracchādayet* / III.53 /

9.6 *eṣa dviśataḥ prastāraḥ* / (III.54) /

9.7 *aparasmin prastāra ātmasraktiṣu catasraḥ*[95] *pādeṣṭakā upadadhyāt* / (III.55) / *tāsāmabhito dve dve ardheṣṭake* / (III.56) / *pūrvasminnanīke pañca* / (III.57) /

9.8 *pakṣāgrayostisrastisro 'dhyardhā udīcīḥ* / (III.58) / *tāsāmantaraleṣveka-ikāmardheṣṭakāṃ prācīm* / (III.59) /

9.9 *śeṣamagniṃ pañcamabhāgīyābhiḥ pracchādayet* / (III.60 /

9.10 *eṣa dviśataḥ prastāro vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (III.61) /

10

10.1 *atha vakrapakṣo vyastapucchaḥ* / (III.62) /

10.2 *tasyeṣṭakāḥ kārayetpuruṣasya caturthyaḥ* / (III.63) / *tāsāmardhyāḥ pādyāśca*[96] / (III.64) / *nityamakṣṇyāpacchedanamanādeśe* / (III.65) /

10.3 *pādeṣṭakāścaturbhiḥ*[97] *parigṛhṇīyādardhapadena padenādhyardhapadena padasaviśeṣeṇeti* / (III.66-67) / *te dve yathā dīrghasaṃśliṣṭe syātāṃ tathār-dheṣṭakāṃ kārayet* / (III.68) /

10.4 *athāgniṃ vimimīta*[98] / *ātmā dvipuruṣāyāmo daśapadavyāsaḥ* / (III.69 / *tasya dakṣiṇādaṃsāduttarato' dhyardhaprakrame lakṣaṇaṃ karoti* / (III.70) / *evamaparataḥ* / (III.71) / *tayorupariṣṭātspandyāṃ niyamyā*[99]*ṃsamapacchin-dyāt* / (III.72) / *etenetarāsāṃ sraktīnāmapacchedā vyākhyātāḥ* / (III.73) / *sa ātmā* / (III.74) /

10.5 *śiro' rdhaṣaṣṭhapadāyāmamardhapuruṣavyāsaṃ* / *tasyāṃsau prakra-meṇa prakrameṇāpacchindyāt* / (III.75) /

10.6 *pucchasya ṣaṭpadā prācī dvipuruṣodīcī* / (III.76) / *tasya pūrve sraktī tribhistribhiḥ prakramairapacchindyāt* / (III.77) /

10.7 *pakṣo dvādaśapadāyāmo daśapadavyāsaḥ* / (III.78 / *tasya madhyāt prāñci*[100] *ṣaṭpadāni prakramya śaṅkuṃ nihanyāt* / (III.79) / *śroṇyorekaikam* /

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[95] *pādeṣu*, M; T omits.

[96] *-śceti*, B. U. M.

[97] *-ṣṭakāṃ caturbhiḥ*, H. U. B. M.

[98] *vimimīte*, T.

[99] Between *niyamya* and *aṃsam*, *anuspandi* in M.

[100] *prāṃcam*, M.

(III.80) / *athainaṃ*[101] *spandyayā paricinuyāt* / (III.81) / *anta*[102]*spandyamapacchidya tatpurastāt prāñcaṃ dadhyāt* / (III.82) / *sa nirṇāmaḥ* / (III.83)/ *etenottarasya pakṣasya nirṇāmo vyākhyātah.* / (III.84) /

10.8 *pakṣāgrayoḥ prakramapramāṇāni pañca pañca caturaśrāṇyanūcīnāni kṛtvā sarvāṇyavāñcamakṣṇayāpacchindyādardhānyuddharet* / (III.85) /

10.9 *evaṃ sāratniprādeśaḥ saptavidhaḥ saṃpadyataḥ* / (I.86) /.

10.10 *upadhāne śiraso' pyaye caturthīmupadadhyāt* / (III.87) / *haṃsamukhī purastāt* / (III.88) / *pādeṣṭake abhitaḥ* (III.89) / *tayoravastādabhitastisrastisraścaturaśrapādyāḥ* / (III.90) / *śeṣe pādeṣṭakāḥ* / (III.91) /

10.11 *api vā śiraso' gre haṃsamukhīmupadadhyāt tasya avastāccaturthīmupadadhyātpādeṣṭake abhitaḥ* / *tayoravastādabhitastisrastisraścaturaśrapādyāḥ*/ *śeṣe pādeṣṭakāḥ* / (III.92) /

10.12 *śiraso' vastātpañcapādeṣṭakā vyatiṣaktā upadadhyāt* / (III. 93)/ *tathā pucchasya purastāt* (III.94) *yadyadapacchinnaṃ tasminnardheṣṭakāḥ pādeṣṭakāścopadadhyāt* / (III.95) /

10.13 *śeṣamagniṃ caturbhāgīyābhiḥ pracchādayet* / (III.96) / *pādyābhiḥ sārdhyābhiḥ saṃkhyāṃ pūrayet* / (III.97) /

10.14 *eṣa dviśataḥ prastāraḥ*[103] /

10.15 *aparasminprastāre haṃsamukhīścatasraścatasṛbhiḥ pādeṣṭakābhiḥ saṃyojayedyathā dīrghacaturaśraṃ saṃpadyate* / *tattiryak svayamātṛṇṇāvakāśa upadadhyāt* / (III.98) /

10.16 *haṃsamukhyau pratīcyau pucchāpyaye*[104] *'rdhapadenātmani viśaye* / (III.99) / *tayoravastādabhitastisraḥ pādeṣṭakāḥ prāṅmukhīrupadadhyāt* / (III.100) /

10.17 *pucchasyāvastātpañcadaśa pādeṣṭakā vyatiṣaktā upadadhyāt* / (III.101) /

10.18 *pādeṣṭake ardheṣṭaketi pakṣapatrāṇāṃ prācīrvyatyāsaṃ cinuyāt* / (III.102) /

10.19 *viśaye yadapacchinnaṃ tasminnardheṣṭakāḥ pādeṣṭakāścopadadhyāt* / (III.103) /

10.20 *śeṣamagniṃ caturbhāgīyābhiḥ pracchādayet* / *pādyābhiḥ sārdhyābhiḥ saṃkhyāṃ pūrayet* / (III.104) /

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[101] *athainām*, T.

[102] *antaḥspandyam*, T.

[103] *eṣa dviśataḥ prastāraḥ* omitted in B, T.

[104] *pucchasyāppaye*, U.

11

11.1 *athāparaḥ*[105]/ (III.105) /

11.2 *puruṣasya pañcamībhiḥ śatamaśītiḥ saptārdhaṃ ca sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / (III.106) /

11.3 *tāsāṃ pañcāśaddve cātmany*-(III.107)-*ardhacaturthyaḥ*[106] *śirasi* / (III.108) / *pañcadaśa pucche* (III.109) / *aṣṭapañcāśatsārdhyā dakṣiṇe pakṣa upadadhyāt* / (III.110) / *tathottare* / (III.111) /

11.4 *ardhavyāyāmena sraktīnāmapacchedaḥ* / (III.112) / *saṃnataṃ pucchaṃ* / (III.113) / *pakṣayostribhistribhiraratnibhir*[107]*apanāmaḥ* / (III.114) / *adhyardhyābhiḥ*[108] *ṣaṭ ṣaṭ patrāṇi kuryāt* / (III.115) / *ākṛtiḥ śiraso nityā* / (III.116) /

11.5 *atheṣṭakānāṃ vikārāḥ* / (III.117) /

11.6 *puruṣasya pañcamyastā evaikato 'dhyardhāḥ* / (III.118) / *tā evaikataḥ sapādāḥ* / (III.119) / *pañcamabhāgīyāyāḥ pādyāḥ sārdhyāḥ* / (III.120) / *tathādhyardhāyāḥ*[109] / (III.121) / *tayoścāṣṭamabhāgau tathā śleṣayedyathā tisraḥ sraktayo bhavanti* / (III.122) / *pañcamabhāgīyāyāścāṣṭamyaḥ* (III.123)/ *tāni daśa* / (III.124) /

11.7 *ātmani pañcamabhāgīyāḥ sārdhyā upadadhyāt* / (III.125) / *tathā pucche* / (III.126) /

11.8 *pakṣayoścādhyardhāḥ sārdhyāḥ* / (III.127) /

11.9 *śirasi yāḥ saṃbhavanti* / (III.128) /

11.10 *aparasminprastāre pūrvayoḥ pakṣāpyayayorekaikāmubhayīmupadadhyāt* / (III.129) / *ekaikāmaparayoḥ* / (III.130) / *dve dve śirasaḥ pārśvayoḥ*/ (III.131) /

11.11 *pucchasyāvastādadhyardhāḥ prācīryathāvakāśam* / (III.132) / *pārśvayoḥ pādyāḥ sāṣṭamabhāgāḥ*[110] / (III.133) /

11.12 *pakṣayoścādhyardhāḥ sāvayavāḥ* / (III.134) /

11.13 *śeṣaṃ yathāyogaṃ yathāsaṃkhyaṃ yathādharmaṃ copadadhyāt* / (III.135) /

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[105] *-param*, M.

[106] *-turthāḥ*, B, T.

[107] *-aratnibharapanāmo* in Caland.

[108] Thus B. *dhyardhābhiḥ*, M, U; *-dhyardhārdhyābhiḥ*, T.

[109] *-stathādhyardhyāyā-*, M. U.

[110] *-bhāgīyāḥ*, M. *sāṣṭabhāgāḥ*, T.

12

12.1 *kaṅkacita etenātmā puccham ca vyākhyātam* / (III.136) /

12.2 *śirasi pañcopadadhyāt* / (III.137 / *tasyākṛtirvyākhyāta* / (III. 138) /

12.3 *saptapañcāśaddakṣiṇe pakṣa upadadhyāt* / (III.139) / *tathottare* / (III.140) /

12.4 *vyāyāmena saprādeśena pakṣayorapanāmaḥ* / (III.141) / *pañcamabhāgīyārdhyābhiḥ ṣaṭ ṣaṭ patrāṇi kuryāt* / (III.142) / *adhyardhāvaśiṣyate* / (III.143) /

12.5 *tayā pucchasyāvastāt pādāvaratnimātrāvaratnyantarālau prādeśavyāsau bhavataḥ* / (III.144) / *tayoravastādabhito dvaudvāvaṣṭamabhāgau prāgbhedāvupadadhyāt* / (III.145) /

12.6 *evaṃ sāratniprādeśaḥ saptavidhaḥ saṃpadyate*[111] / (III.146) /

12.7 *atheṣṭakānāṃ vikārāḥ* / *pañcamabhāgīyāḥ sāvayavāḥ* / (III.147) / *pādeṣṭakāṃ caturbhiḥ*[112] *parigṛhṇīyād*-(III.148)-*ardhaprādeśenādhyardhaprādeśena prādeśena prādeśasaviśeṣeneti*/(III.149)/ *adhyardheṣṭakāṃ caturbhiḥ*[112] *parigṛhṇīyādardhavyāyāmena dvābhyāmaratnibhyāmaratnisaviśeṣeneti* / (III.150) / *tāḥ ṣaṭ* / (III.151) /

12.8 *tāsāṃ caturaśrapādyāḥ sāṣṭamabhāgāḥ pādayorupadhāya śeṣaṃ yathāyogaṃ yathāsaṃkhyaṃ yathādharmaṃ copadadhyāt* / (III.152) /

13

13.1 *alajacita etenātmā śiraḥ puccham ca vyākhyātaṃ pādāvapoddhṛtya* / (III.153) /

13.2 *triṣaṣṭirdakṣiṇe pakṣa upadadhyāt* / (III.154) / *tathottare* / (III.155) /

13.3 *puruṣeṇa pakṣayorapanāmaḥ* / (III.156) /

13.4 *aparasmādapanāmātprāñcamaratnim mitvā tasminspandyāṃ niyamyāparaṃ pakṣapatrāpacched*[113]*amanvāyacchet* / (III.157) /

13.5 *evaṃ pañca pañcamyaḥ sārdhyā uddhṛtā bhavanti* / (III.158) /

13.6 *pādeṣṭakāmapanāma*[114] *upadhyāya* (III.159) *tāsāṃ caturaśra pādyāḥ sāṣṭamabhāgā apoddhṛtya śeṣaṃ*[115] *yathāyogaṃ yathāsaṃkhyaṃ yathādharmaṃ copadadhyāt* / (III.160) /

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[111] *śiraso nityā*, ins. M.
[112] *pādeṣṭakāścaturbhiḥ*, M.
[113] *pakṣapatramapache-*, M; *pakṣayamnāpache-*, B.
[114] *pādeṣṭakānāmavanāma*, B.
[115] *śeṣā*, T.

14

14.1 *praugacitaṃ cinvīteti*[116] / (III.161) /

14.2 *yāvānagniḥ sāratniprādeśastāvatpraugaṃ kṛtvā tasyāparasyāḥ karaṇyā dvādaśeneṣṭakāstadardhavyāsāḥ kārayet* / (III.162) / *tāsāmardhyāḥ pādyāśca* / (III.163) /

14.3 *tāsāṃ dve ardheṣṭake bāhyasaviśeṣe*[117] *cubuka upadadhyādardhyāścāntayoḥ* / (III.164-165) /

14.4 *śeṣamagniṃ bṛhatībhiḥ*[118] *pracchādayedardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.166) /

14.5 *aparasminprastāre' parasminnanīke saptacatvāriṃśatpādeṣṭakā vyatiṣaktā upadadhyāt* / (III.167) /

14.6 *cubuka ekāṃ śūlapādyām*[119] / (III.168) /

14.7 *dīrghe cetare catasraḥ svayamātṛṇṇāvakāśa upadadhyād-* (III.169)- *ardhyāścāntayoḥ* / (III. 170) /

14.8 *śeṣamagniṃ bṛhatībhiḥ prācībhiḥ pracchādayedardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.171) /

15

15.1 *ubhayataḥ praugaṃ cinvīteti* / (III.172) /

15.2 *yāvānagniḥ sāratniprādeśastāvadubhayataḥ praugaṃ kṛtvā* (III.173) *navamena tiryaṅmānyāḥ praugacitoktā vikārāḥ* / (III.174) /

15.3 *tathopadhānam* / (III.175) /

15.4 *aparasminprastāre cubukayordve pādeṣṭake upadadhyāt* / (III.176) / *saṃdhyantayośca dīrghapādye* / (III.177) /

15.5 *dīrghe cetare ca*[120] *catasraḥ svayamātṛṇṇāvakāśa upadadhyādardhyāścāntayoḥ* / (III.178) /

15.6 *śeṣamagniṃ bṛhatībhiḥ prācībhiḥ*[121] *pracchādayedardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.178) /

16

16.1 *rathacakracitaṃ cinvīteti vijñāyate* / (III.179) /

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[116] *iti* omitted in T.
[117] Thus H. U. B. M.; *bāhyaviśeṣe*, T.
[118] M. ins *prācībhiḥ*
[119] T. omits it in the text, but mentions it in the commentary.
[120] Omitted in T.
[121] Omitted in T.

16.2 *dvayāni tu*[122] *khalu rathacakrāṇi bhavanti* (III.180) *sārāṇi ca pradhiyuktāni ca* / (III.181) / *aviśeṣātte manyāmahe' nyatarasyākṛtiriti* / (III.182)/

16.3 *athāgnim vimimīte* / *yāvānagniḥ sāratniprādeśastāvatīṃ bhūmiṃ parimaṇḍalāṃ kṛtvā tasminyāvatsaṃbhavettāvat*[123]*samacaturaśram kṛtvā* (III.183) *tasya karaṇyā dvādaśeneṣṭakāḥ kārayet* / (III.184) /

16.4 *tāsāṃ ṣaṭ pradhāvupadhāya śeṣamaṣṭadhā vibhajet*[124] / (III.185) /

16.5 *aparaṃ prastāraṃ tathopadadhyādyathā pradhyanīkeṣu sraktayo bhavanti*[125] / (III.186) /

16.6 *athāparaḥ* / (III.187) /

16.7 *puruṣārdhātpañcadaśeneṣṭakāḥ samacaturaśrāḥ kārayenmānārthāḥ* / (III.188) /

16.8 *tāsāṃ dve śate pañcaviṃśatiśca sāratniprādeśaḥ saptavidhaḥ saṃpadyate*/ (III.189) /

16.9 *tāsvanyāścatuḥṣaṣṭimāvapet* / (III.190) / *tābhiḥ samacaturaśraṃ karoti* / (III.191) / *tasya ṣoḍaśeṣṭakā pārśvamānī bhavati* / (III.192) / *trayastriṃśadatiśiṣyante* / (III.193) / *tābhirantānsarvaśaḥ*[126] *paricinuyāt* / (III.194) /

16.10 *nābhiḥ ṣoḍaśa madhyamāḥ* / (III.195) / *catuḥṣaṣṭirarāścatuḥṣaṣṭirvediḥ* / (III.196) / *nemiḥ śeṣāḥ* / (III.197) /

16.11 *nābhimantataḥ parilikhet* / (III.198) / *nemimantataścāntarataśca*[127] *parilikhya* / (III.199) / *nemīnābhyorantarālaṃ dvātriṃśaddhā*[128] *vibhajya viparyāsaṃ bhāgānuddharet* / (III.200) / *evamāvāpa uddhṛto bhavati* / (III.201) /

16.12 *nemiṃ catuḥṣaṣṭiṃ kṛtvā vyavalikhya madhye parikṛṣet* / (III.202)/ *tā aṣṭāviṃśatiśataṃ*[129] *bhavanti* / (III.203) /

16.13 *arāṃścaturdhā caturdhā*[130] (III.204) *nābhimaṣṭadhā vibhajet* / (III.205) /

16.14 *eṣa prathamaḥ prastāraḥ*[131] /

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[122] Not in the text as given by T.

[123] *tāvat* not in T.

[124] After *vibhajet* U ins. *asminprastāre caturaśrasraktiravāntaradeśātpratisaṃpādayed-*.

[125] After *bhavanti* U ins. *iti*.

[126] *-sarvataḥ*, T.

[127] *-mimaṃtataḥ paryasya tasya parilikhennemi*, M; B omits *parilikhya*.

[128] *-triṃśadhā*, T.

[129] Thus T and U; *aṣṭāviṃśacchataṃ*, B; *aṣṭācatvāriṃśacchataṃ*, M.

[130] Thus U, M; *vibhajet* instead of the second *caturdhā*, B, T.

[131] *eṣa prathamaḥ prastāraḥ* omitted in T.

16.15 *aparasminprastāre* (III.206) *nābhimantataścaturthavelāyāṃ parikṛṣet* / (III.207) / *nemimantarataḥ* / (III.208) /

16.16 *nemimantarataś*[132]*catuḥṣaṣṭiṃ kṛtvā vyavalikhet* / (III.209) /

16.17 *arāṇāṃ pañcadhā vibhāga āparikarṣaṇayoḥ* / (III.210) /

16.18 *nemyāmantarāleṣu dve dve* (III.211) *nābhyāmantarāleṣvekaikāṃ* / (III.212) /

16.19 *yaccheṣaṃ nābhestadaṣṭadhā vibhajet* / (III.213) /

16.20 *sa eṣa ṣoḍaśakaraṇaḥ sāro rathacakracit* / (III.214) /

17

17.1 *droṇacitaṃ cinvīteti vijñāyate* / (III.215) /

17.2 *dvayāni tu khalu droṇāni bhavanti*[133] (III.216) *caturaśrāṇi ca parimaṇḍalāni ca* / (III.217) / *aviśeṣātte manyāmahe' nyatarasyākṛtiriti* / (III.218) /

17.3 *athāgniṃ vimimīte* / *caturaśra ātmā bhavati* / (III.219) / *tasya trayaḥ puruṣāstribhāgonāḥ pārśvamānī*[134] / (III.220) /

17.4 *paścāttsarurbhavati* / (III.221) / *tasyārdhapuruṣo daśāṅgulāni ca prācī* / (III.222) / *tribhāgonaḥ puruṣa udīcīti*[135] / (III.223) /

17.5 *evaṃ sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / (III.224) /

17.6 *atheṣṭakānāṃ vikārāḥ*[136] / *puruṣasya ṣaṣṭhyastā evaikato' dhyardhāḥ* / *tāsāmardhyāstiryagbhedāḥ puruṣasya caturthya iti* / (III.225) /

17.7 *tāsāṃ tsaruśroṇyantarālayoḥ ṣaṭ*[137] *ṣaṣṭīrupadhāya śeṣamagniṃ bṛhatībhiḥ pracchādayet* / (III.226) / *ardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.227) /

17.8 *aparasminprastāre dakṣiṇe' ṃse' dhyardhāmudīcīmupadadhyāt* / (III.228) / *tathottare* / (III.229) /

17.9 *pūrvasminnanīke ṣaḍbhāgīyā upadadhyāt* / (III.230) /

17.10 *dakṣiṇottarayoścaturbhāgīyāḥ* / (III.231) /

17.11 *tsaroḥ purastātpārśvayordve caturbhāgīye upadadhyāt* / (III.232 /

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[132] *nemyaṃtarata*, U; *nemyaṃta*, M; *nemimaṃtata*, B.

[133] Only in U; in T, it occurs in the commentary.

[134] T. has *bhavati* after *pārśvamānī*.

[135] U. omits *iti*.

[136] In T, *tasyeṣṭakāḥ kārayet* in place of *atheṣṭakānāṃ vikārāḥ*.

[137] *ṣaṭ ṣaṭ* in T

tayoravastādabhito dve dve adhyardhe viṣūcī / (III.233) / *tayoravastānmadhyadeśe*[138] *dve*[139] *ṣaṣṭhyau prācyau* / (III.234) /

17.12 *śeṣamagniṃ bṛhatībhiḥ prācībhiḥ*[140] *pracchādayet* / (III.235) / *ardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.236) /

18

18.1 *athāparaḥ* / (III.237) /

18.2 *puruṣasya ṣoḍaśībhirviṃśaśataṃ*[141] *sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / (III.238) /

18.3 *tāsāmekāmapoddhṛtya śeṣāḥ parimaṇḍalaṃ karoti* / (III.239 /

18.4 *tatpūrveṇa rathacakracitā vyākhyātam* / (III.240) /

18.5 *ṣoḍaśīṃ purastādviśaya upadhāya tayā saha maṇḍalaṃ*[142] *parilikhet* / (III.241) /

18.6 *yadavastādapacchinnaṃ tatpurastādupadadhyāt* / (III.242) /

18.7 *pradhīnāṃ saptadhā vibhāgaḥ* / (III.243) /

18.8 *pradhimadhyamāḥ prakramavyāsā bhavanti* / (III.244) /

18.9 *caturaśrāṇāmardhyābhiḥ saṃkhyāṃ pūrayet* / (III.245) /

18.10 *aparasminprastāre* (III.246) *pradhimadhyamāmoṣṭha upadhāya yadavastāttaddvedhā vibhajet* / (III.247) /

18.11 *sa eṣa navakaraṇo droṇacitparimaṇḍalaḥ* / (III.248) /

18.12 *samūhya paricāyyau pūrveṇa rathacakracitā vyākhyātau* / (III.249) /

18.13 *samūhyasya dikṣu cātvālān khānayitvā*[143] *tebhyaḥ purīṣaṃ samūhyopadadhyāt* / (III.250) /

18.14 *paricāyya iṣṭakānāṃ deśabhedaḥ* / (III.251) /

18.15 *taṃ sarvābhiḥ pradakṣiṇaṃ paricinuyāt* / (III.252) /

19

19.1 *śmaśānacitaṃ cinvīteti vijñāyate* / (III.253) /

19.2 *sarvamagniṃ caturaśrānpañcadaśa bhāgānkṛtvā* (III.253) *teṣāmākhyātamupadhānam* / (III.254) /

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[138] *madhyedeśe*, B.

[139] Omitted in B, T.

[140] Omitted in U, T.

[141] *-viṃśaṃśataṃ*, B; *viṃśatiśataṃ*, M.

[142] *parimaṇḍalaṃ*, M.

[143] *khātayitvā*, T.

19.3 *tribhirbhāgairbhāgārdhavyāsaṃ*[144] *dīrghacaturaśraṃ vihṛtya pūrvasyāḥ karaṇyā madhyāc*[145]*chroṇī pratyālikhyāntāvuddharet* / (III.255) / *tasya daśadhā vibhāgaḥ* / (III.256) /

19.4 *tāni viṃśatiḥ sarvo' gniḥ saṃpadyate* / (III.257) /

19.5 *aparasminprastāre* (III.258) *praugamadhye'*[146] *nūcīnaṃ vibhajet* / (III.259) / *tasya ṣaḍdhā vibhāgaḥ* /(III.260) / *te dve pārśvayorupadadhyāt* / (III.261) /

19.6 *bhāgatṛtīyāyāmaścaturthavyāsāḥ kārayet* / (III.262) / *tāsām-ardhyāstiryagbhedāḥ* / (III.263) /

19.7 *tā antayorupadhāya śeṣamagniṃ bṛhatībhiḥ prācībhiḥ pracchādayet* / (III.264) / *ardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.265) /

19.8 *ūrdhvapramāṇamagneḥ pañcamena vardhayet* / (III.266) /

19.9 *tatsarvaṃ tredhā vibhajya dvayorbhāgayoścaturthena vā navamena*[147] *vā caturdaśena veṣṭakāḥ kārayet* / (III.267) /

19.10 *tābhiścatasro vā nava vā caturdaśa vā citir*[148]*upadhāya śeṣamavāñca-makṣṇayāpacchindyāt* / *ardhamuddharet* / (III.268) /

19.11 *tasya nityo vibhāgo yathāyogamiṣṭakānāṃ hrāsavṛddhī* / (III.269) /

20

20.1 *kūrmacitaṃ cinvīta yaḥ kāmayeta brahmalokamabhijayeyamiti* / (III.270) / *vijñāyate*[149] /

20.2 *dvayāḥ khalu kūrmā bhavanti vakrāṅgāśca parimaṇḍalāśca*[150] / (III.271) / *aviśeṣātte manyāmahe' nyatarasyākṛtiriti* / (III.272) /

20.3 *athāgniṃ vimimīte* / *caturaśra ātmā bhavati* / *tasya daśa prakramāḥ pārśvamānī bhavati* / (III.273) / *tasya dvābhyāṃ dvābhyāṃ prakramābhyāṃ sraktīnāmapacchedaḥ* / (III.274) /

20.4 *pūrvasminnanīke prakramapramāṇāni catvāri caturaśrāṇi kṛtvā teṣāṃ ye antye te akṣṇayāpacchindyāt* / (III.275) / *evaṃ dakṣiṇata evaṃ paścādevamuttarataḥ* / (III.276) / *sa ātmā* / (III.277) /

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[144] B. omits *bhāgārdha*.

[145] H. U. B. M.; *ardhācchroṇi*, T.

[146] *pradhimadhye*, B.

[147] *paṃcamena*, M.

[148] *vadhīrupadhāya*, M.

[149] Not in T.

[150] *parimaṇḍalāṅgā*,

20.5 *śiraḥ pañcapadāyāmamardhapuruṣavyāsam* / (III.278) / *tasyāṃsau prakrameṇa*[151]*prakrameṇāpacchindyāt* / (III.279) /

20.6 *sraktyapacchede pādānunnayet* / (III.280) / *tasya dvipadākṣṇayā tiraścī taddviguṇāyāmamanūcī* / (III.281) / *tasya dvipadākṣṇayā pūrvamaṃsamapacchindyāt*/(III.282) / *etenetareṣāṃ pādānāmapacchedā vyākhyātāḥ*/ (III.283) / *aparayoḥ pādayoraparāvaṃsā*[152]*vapacchindyāt* / (III.284) /

20.7 *evaṃ sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / (III.285) /

20.8 *tasyeṣṭakāḥ kārayetpuruṣasya caturthyas*[153] *tāsāmardhyāḥ pādyāśca* / (III.286) /

20.9 *adhyardhapādyāścaturbhiḥ*[154] *parigṛhṇīyātprakrameṇa dvābhyāṃ padābhyāṃ padasaviśeṣeṇeti* / (III.287) /

20.10 *te dve*[155] *yathā dīrghasaṃśliṣṭe syātāṃ tathaikāṃ kārayet* / (288) /

20.11 *dvipadākṣṇayārdhena samacaturaśrāmekām* / (III.289) /

20.12 *upadhāne śiraso' gre caturaśrāmupadadhyāt* / (III.290) / *haṃsamukhyāvavastāt* / (III.291) /

20.13 *pañca pañca caturaśrā dve dve pādeṣṭake iti pādeṣūpadadhyāt*/(III.292)/

20.14 *yadyadapacchinnaṃ tasminnardheṣṭakā*[156] *upadadhyāt* / (III.293) /

20.15 *śeṣamagniṃ caturbhāgīyābhiḥ pracchādayet* / (III.294) / *ardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.295) /

20.16 *aparasminprastāre śiraso' gre haṃsamukhīmupadadhyātpā leṣṭake abhitaḥ* / (III.296) /

20.17 *tayoravastādabhito dve dve adhyardha*[157]*pādye viṣūcī* / (III.297) /

20.18 *tayoravastādabhitaśchedasaṃhite dve pādeṣṭake* / (III.298) /

20.19 *dve dve dvipade tisrastisro' rdheṣṭakā iti pādeṣūpadadhyāt* / (III.299)/

20.20 *yadyad*[158]*apacchinnaṃ tasminnardheṣṭakāḥ pādeṣṭakaścopadadhyāt* / (III.300) /

20.21 *śeṣamagniṃ caturbhāgīyābhiḥ pracchādayet* / (III.301) / *ardheṣṭakābhiḥ saṃkhyāṃ pūrayet* / (III.302) /

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[151] *prakrameṇa* once, M, T.

[152] *-raparāṃsāvapa-*, M. T.

[153] *caturthīstā-*, B.

[154] *-dhyardhāpādyāṃ caturbhiḥ*, T.

[155] T. omits.

[156] Thus M; *tasminnardheṣṭakāścopa-*, B. and T.; *tasminnardheṣṭakāḥ pādeṣṭakāścopa-*, U.

[157] *adhyardhā*, T.

[158] *yadapacchinnaṃ*, T.

21

21.1 *athāparaḥ* / (III.303) /

21.2 *puruṣasya ṣoḍaśībhirviṃśaśatam*[159] *sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / (III.304) /

21.3 *tāsāṃ pañca ṣoḍaśīrapoddhṛtya śeṣāḥ parimaṇḍalaṃ karoti* / (III.305)/ *taduttareṇa droṇacitā vyākhyātam* / (III.306) /

21.4 *atha tāḥ*[160] *pañca ṣoḍaśyastābhiravāntaradikṣu pādānunnayec*[161]*chiraḥ purastāt* / (III.307-308) / *tāsāṃ parikarṣaṇaṃ vyākhyātam* / (III.309) /

21.5 *pradhīnāṃ saptadhā vibhāgaḥ* / *pradhimadhyamāḥ*[162] *prakramavyāsā bhavanti* / (III.310) /

21.6 *yadatiriktaṃ saṃpadyate taccaturaśrāṇāmadhyardhābhiryoyujyeta*[163] / (III.311) /

21.7 *aparasminprastāre pādānāṃ śirovadvibhāgaḥ śirasaḥ pādavat* / (III.312-313) /

21.8 *vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (III.314) /

21.9 *kūrmasyānte tanu purīṣamupadadhyānmadhye bahulam*/(III.315-316)/ *etadeva*[164] *droṇe viparītam* / (III.317) /

21.10 *atha haika ekavidhaprabhṛtīnpraugādīn bruvate* / (III.318) /

21.11 *samacaturaśrāneka ācāryāḥ* / (III.319) / *tasya karaṇyā dvādaśeneṣṭakāḥ kārāyettāsāmardhyāḥ pādyāśca* / (III.320) /

21.12 *athāśvamedhikasyāgneḥ puruṣābhyāso nāratniprādeśānāṃ* / (III.321)/

21.13 *prākṛto*[165] *vā triguṇaḥ* / *tristāvo' gnirbhavatītyekaviṃśo' agnirbhavatītyubhayaṃ brāhmaṇamubhayaṃ brāhmaṇam* / (III.322-323) /

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[159] *-viśaṃśatam*, B. U.; *viṃśataṃśatam*, M.
[160] *yāḥ*, T.
[161] *pañcamyāṃ* before *śiraḥ*, T.
[162] H. U. B. M.; *pradhimadhyāḥ*, T.
[163] *-yoyujyate*, T.
[164] *eva* only in U and in one of T's Mss; omitted in T.
[165] Thus H. U.; *prakṛtau*, B; *tā*, M.

ĀPASTAMBA-ŚULBASŪTRA

1

1.1* *vihārayogānvyākhyāsyāmaḥ* |

1.2 *yāvadāyāmaṃ pramāṇaṃ tadardhamabhyasyāparasmiṃstṛtīye ṣaḍbhāgone lakṣmaṇaṃ karoti* | *pṛṣṭhyāntayorantau niyamya lakṣaṇena dakṣiṇāpāyamya nimittaṃ karoti* | *evamuttarato viparyasyetarataḥ* | *sa samādhiḥ* | *tannimitto nirhāso vivṛddhirvā* |

1.3 *āyāmaṃ*[1] *vābhyasyāgantucaturthamāyāmasyā*[2]*kṣṇayārajjuḥ tiryaṅmānīśeṣaḥ* | *vyākhyātaṃ viharaṇam*[3] |

1.4 *dīrghasyākṣṇayārajjuḥ pārśvamānī tiryaṅmānī*[4] *ca yatpṛthagbhūte kurutastadubhayaṃ karoti* | *tābhirjñeyābhiruktaṃ viharaṇam* |

1.5 *caturaśrasyākṣṇayārajjurdvistāvatīṃ bhūmiṃ karoti* | *samasya dvikaraṇī* |

1.6 *pramāṇaṃ tṛtīyena vardhayettacca*[5] *caturthenātmacatustriṃśonena saviśeṣaḥ*[6] |

1.7 *athāparam*[7] | *pramāṇamātrīṃ rajjumubhayataḥ pāśāṃ karoti* | *madhye lakṣaṇamardhamadhyayośca*[8] *pṛṣṭhyāyāṃ rajjumāyamya pāśayorlakṣaṇeṣviti śaṅkūn*[9] *nihatyopāntyayoḥ pāśau pratimucya madhyamena lakṣaṇena dakṣiṇāpāyamya*[10] *nimittaṃ karoti* | *madhyame pāśau pratimucya uparyupari nimittaṃ madhyamena lakṣaṇena dakṣiṇāpāyamya śaṅkuṃ nihanti* | *tasminpāśaṃ pratimucya pūrvasminnitaraṃ madhyamena lakṣaṇena dakṣiṇamaṃsamāyacchet* | *unmucya pūrvasmādaparasminpratimucya madhyamenaiva lakṣaṇena dakṣiṇāṃ śroṇīmāyacchet* | *evamuttarau śroṇyaṃsau* |

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* Bürk's numbering has been generally retained ; wherever deviations have been made, his numbering has been given within parenthesis in the text.

1 D. begins with *atha yogāntaram.*

2 *āyāmaśca*, BK.

3 D. omits.

4 D. omits.

5 MU omits.

6 *sa viśeṣaḥ*, MU.

7 BK, MU.

8 *-madhyamayośca*, MU.

9 *śaṅkuṃ*, MU

10 MU ins. *śaṅkuṃ* after *-pāyamya*.

2

2.1 *athāparoyogaḥ | pṛṣṭhyāntayormadhye ca śaṅkūn*[11] *nihatyārdhe*[12] *tadviśeṣamabhyasya lakṣaṇaṃ kṛtvārdhamāgamayet | antayoḥ*[13] *pāśau kṛtvā madhyame saviśeṣaṃ pratimucya pūrvasminnitaraṃ lakṣaṇena dakṣiṇamaṃsamāyacchet | unmucya pūrvasmādaparasminpratimucya lakṣaṇenaiva dakṣiṇāṃ śroṇīmāyacchet | evamuttarau śroṇyaṃsau |*

2.2 *pramāṇaṃ tiryagdvikaraṇyāyāmastasyākṣṇayārajjustrikaraṇī |*

2.3 *tṛtīyakaraṇyetena vyākhyāta | vibhāgastu navadhā |*

2.4 *tulyayoścaturaśrayoruktassamāsaḥ | nānā pramāṇayoścaturaśrayossamāsaḥ | hrasīyasaḥ karaṇyā varṣīyaso vṛdhram*[14] *ullikhet | vṛdhrasyākṣṇayārajjurubhe samasyati | taduktam |*

2.5 *caturaśrāccaturaśraṃ nirjihīrṣan yāvannirjihīrṣettasya karaṇyā varṣīyaso*[15] *vṛdhramullikhet | vṛdhrasya pārśvamānīmakṣṇayetaratpārśvamupasaṃharet | sā yatra nipatettadapacchindyāt | chinnayā nirastam |*

2.6 *upasaṃhṛtā akṣṇayārajjussā catuṣkaraṇī chinnā cetarā ca yatpṛthagbhūte kurutaḥ tadubhayaṃ karoti | tiryaṅmānī puruṣaṃ śeṣastrīn*[16] *| taduktam |*

2.7 *dīrghacaturaśraṃ samacaturaśraṃ cikīrṣan tiryaṅmānyā apacchidya śeṣaṃ vibhajyobhayata upadadhyāt | khaṇḍamāgantunā saṃpūrayet | tasya nirhāra*[17] *uktaḥ |*

3

3.1 *samacaturaśraṃ dīrghacaturaśraṃ cikīrṣan yāvaccikīrṣet tāvatīṃ pārśvamānīṃ kṛtvā yadadhikaṃ syāttadyathā*[18] *yogamupadadhyāt |*

3.2 *caturaśraṃ maṇḍalaṃ cikīrṣan madhyātkoṭyāṃ nipātayet | pārśvataḥ parikṛṣyātiśayatṛtīyena saha maṇḍalaṃ parilikhet | sā nityā*[19] *maṇḍalam*[20] *| yāvaddhīyate tāvadāgantu |*

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[11] *śaṅkuṃ*, MU, S.
[12] *ardhe* repeated in MU.
[13] *antyayoḥ*, MU, D.
[14] *vṛddhram-*, D, MU.
[15] MU omits.
[16] *-strīṃ*, BK.
[17] *nirhāsa*, MU
[18] *tad*, not in MU.
[19] Thus BK, MU; *sānityā*, according to comm.
[20] S. omits.

3.3 *maṇḍalaṃ caturaśraṃ cikīrṣan viṣkambhaṃ pañcadaśabhāgānkṛtvā dvāvuddharet / trayodaśāvaśiṣyante / sānityā*[21] *caturaśram /*

3.4 *pramāṇena pramāṇaṃ vidhīyate /*

3.5 *caturaśram*[22] *ādeśādanyat /*

3.6 *dvābhyāṃ catvāri / tribhirnava /*

3.7 *yāvatpramāṇā rajjustāvatastāvato vargān karoti / tathopalabdhiḥ /*

3.8 *adhyardhapuruṣā rajjurdvau sapādau*[23] *karoti / ardhatṛtīyapuruṣā ṣaṭ sapādān /*

3.9 *athātyanta pradeśaḥ*[24] */ yāvatā yāvatā*[25] *'dhikena parilikhati tatpārśvayorupadadhāti / yacca tena caturaśraṃ kṛyate tatkoṭyām /*

3.10 *ardhapramāṇena pādapramāṇaṃ vidhīyate / ardhasya dvipramāṇāyāḥ pādapūraṇatvāt / tṛtīyena navamī kalā /*

4

4.1 *agnyādheyike vihāre gārhapatyāhavanīyayorantarāle vijñāyate / aṣṭāsu prakrameṣu brāhamaṇo' gnimādadhīta / ekādaśasu rājanyaḥ / dvādaśasu vaiśyaḥ /*

4.2 *caturviṃśatyāmaparimite*[26] *yāvatā vā cakṣuṣā manyate tasmānnātidūramādheya iti sarveṣāmaviśeṣeṇa śrūyate /*

4.3 *dakṣiṇataḥ purastādvitṛtīyadeśe gārhapatyasya nedīyasi dakṣiṇāgnervijñāyate /*

4.4 *gārhapatyāhavanīyayorantarālaṃ pañcadhā ṣaḍdhā vā saṃvibhajya*[27] *ṣaṣṭhaṃ saptamaṃ vā bhāgamāgantumupasamasya*[28] *samaṃ traidhaṃ vibhajyāparasmiṃstṛtīye lakṣaṇaṃ kṛtvā gārhapatyāhavanīyayorantau niyamya lakṣaṇena dakṣiṇāpāyamya nimittaṃ karoti / taddakṣiṇāgnerāyatanam / śrutisāmarthyāt /*

4.5 *yajamānamātrī prācyaparimitā vā yathāsannāni havīṃṣi saṃbhavedevaṃ tiraścīprāñcau vedyaṃsāvunnayati / pratīcī śroṇī / purastādaṃhīyasī paścātprathīyasī madhye saṃnatataraivamiva hi yoṣeti dārśikyā vedervijñāyate /*

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[21] Thus MU; *sā nityā*, BK.

[22] *caturaśraṃ*, not in MU.

[23] *savādau*, MU.

[24] *prādeśaḥ*, D.

[25] *yāvatā* once in D.

[26] *aparicite*, MU.

[27] *saṃbhujya*, BK.

[28] Thus MU & most Mss; *upasamasyāgantu-*, BK.

4.6 *apareṇāhavanīyaṃ yajamānamātraṃ*[29] *dīrghacaturaśraṃ*[30] *viḥṛtya tāvatīṃ rajjumabhyasya*[31] *madhye lakṣaṇaṃ kṛtvā dakṣiṇayoḥ śroṇyaṃsayorantau*[32] *niyamya lakṣaṇena dakṣiṇāpāyamya nimittaṃ karoti / nimitte rajjuṃ niyamyāntau samasyet*[33] */ dakṣiṇāyāḥ śroṇerdakṣiṇamaṃsamālikhet / evamuttarataḥ tiryaṅmānīṃ dviguṇāṃ tathā kṛtvā paścātpurastāccopalikhet*[34] */ vimitāyāṃ purastāt pārśvamānyā upasaṃharet / śrutisāmarthyāt /*

5

5.1 *triṃśatpadāni prakramā vā paścāttiraścī bhavati ṣaṭtriṃśatprācī caturviṃśatiḥ purastāttiraścīti saumikyā vedervijñāyate /*

5.2 *ṣaṭtriṃśikāyāmaṣṭādaśopasamasya aparasmādantāddvādaśasu lakṣaṇaṃ pañcadaśasu lakṣaṇaṃ pṛṣṭhyāntayorantau niyamya pañcadaśikena*[35] *dakṣiṇāpāyamya śaṅkuṃ nihantyevamuttaratastе*[36] *śroṇī / viparyasyāṃsau*[37] *pañcadaśike*[38]*naivāpāyamya*[39] *dvādaśike śaṅkuṃ nihanti / evamuttaratastāvaṃsau / tadekarajjvā viharaṇam /*

5.3 *trikacatuṣkayoḥ pañcikā' kṣṇayārajjuḥ / tābhistrirabhyastābhiraṃsau / caturabhyastābhiḥ śroṇī /*

5.4 *dvādaśikapañcikayostrayodaśikā' kṣṇayārajjuḥ tābhiraṃsau dvirabhyastābhiḥ śroṇī /*

5.5 *pañcadaśikāṣṭikayoḥ saptadaśikā' kṣṇayārajjuḥ tābhiḥ śroṇī / dvādaśikapañcatriṃśikayossaptatriṃśikā' kṣṇayārajjuḥ tābhiraṃsau /*

5.6 *etāvanti jñeyāni vediviharaṇāni bhavanti /*

5.7 *aṣṭāviṃśatyūnaṃ padasahasraṃ mahāvediḥ / dakṣiṇasmādaṃsāddvādaśasu dakṣiṇasyāṃ śroṇyāṃ nipātayet / chedaṃ viparyasyetarata*[40] *upadadhyāt / sā dīrghacaturaśrā / tathā yuktāṃ saṃcakṣīta /*

5.8 *saumikyā veditṛtīye*[41] *yajeteti sautrāmaṇyā vedervijñāyate*[42] */ prakramasya tṛtīyakaraṇī prakramasthānīyā bhavati / trikaraṇyā vā aṣṭika daśike tiryaṅmānyau*

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[29] *yajamānamātrī*, MU.
[30] *dīrghaṃ caturaśraṃ*, MU.
[31] *āyamya*, MU.
[32] *-antarā*, MU.
[33] *samasya*, BK.
[34] Thus in D, Gr, MU, BK. *parilikhet*, S.
[35] *pañcadaśakena*, MU.
[36] *te* not in MU.
[37] *viparyastayāṃsau*, MU.
[38] *-daśakena*, MU.
[39] *-apāyamya*, not in D.
[40] *-syottarata*, MU; *-sya-ttarata*, S.
[41] *vederbitṛtīyadeśe*, MU.
[42] *veder-*, not in BK.

dvādasikā pṛṣṭhyā / (5.8) / *trīṇi caturviṃśāni padaśatāni sautrāmaṇikī vediḥ* / (5.9) /

6

6.1 *dvistāvā*[43] *vedirbhavatītyaśvamedhe vijñāyate* / (5.10) / *prakramasya dvikaraṇī prakramasthānīyā bhavati* / (6.1) /

6.2 *prakramo dvipadastripado vā* / *prakrame yathākāmī śabdārthasya viśayitvāt* / *yajamānasyādhvaryorvā* / *eṣa hi ceṣṭānāṃ kartā bhavati* /

6.3 *rathamātrī nirudhapaśubandhasya vedirbhatīti vijñāyate* / *tatra*[44] *khalvāhūrathākṣamātrī paścāttiryagīṣayā prācī* / *vipathayugena purastāt* / *yāvatā vā*[45] *bāhye chidre* /

6.4 *tadekarajjvoktam* / *pañcadaśikenaivāpāyamyārdhākṣeṇārdhayugeneti*[46] *śroṇyaṃsānnirharet* /

6.5 *athāpyudāharanti* / *aṣṭāśītiśatamīṣā tiryagakṣaścatuśśataṃ ṣaḍaśītiryugaṃ cāsya sa*[47] *rathaścāraṇa ucyate* / *iti rathaparimāṇam* /

6.6 *aratnibhirvā caturbhiḥ paścāt ṣaḍbhiḥ prācī tribhiḥ purastāt* / *tadekarajjvoktaṃ pañcadaśikenaivāpāyamya dvābhyāmadhyardheneti śroṇyaṃsānnirharet* /

6.7 *yajamānamātrī catuḥsraktirbhavatīti paitṛkyā vedervijñāyate* / *tadekarajjvoktaṃ pañcadaśikenaivāpāyamyārdhena tataśśroṇyaṃsānnirharet*[48] /

6.8 *daśapadottara*[49]*vedirbhavatīti some vijñāyate* / *tadekarajjvoktaṃ pañcadaśikenaivāpāyamyārdhena tataś*[50]*śroṇyaṃsānnirharet* /

6.9 *tāṃ yugena yajamānasya vā padairvimāya śamyayā parimimīte* /

6.10 *pade yuge' ratnāviyati śamyāyāṃ ca mānārtheṣu yathākāmī*[51] *śabdārthasya viśayitvāt* /

6.11 *vimitāyāṃ purastātpārśvamānyā*[52] *vupasaṃharet* / *śrutisāmarthyāt* /

7

7.1 *navāratni tiryaksaptaviṃśatirudagāyatamiti sadaso vijñāyate* / (7.1) /

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[43] *dvistāvān*, Gr.
[44] *tasya*, MU.
[45] Missed in D.
[46] *-iti*, not in MU.
[47] Not in MU.
[48] Not in S.
[49] *-dottarā*, MU.
[50] Not in S.
[51] *yāthākāmī*, BK.
[52] *-mānyā upasaṃ-*, MU.

aṣṭādaśetyekeṣām / (7.2) / *tadekarajjvoktaṃ pañcadaśikenaivāpāyamyārdha-pañcamaiḥ*[53] *śroṇyaṃsānnirharet* / (7.3) /

7.2 *prādeśamukhāḥ prādeśāntarālā bhavantītyuparavāṇāṃ vijnāyate* / *aratnimātraṃ caturaśraṃ vihṛtya sraktiṣu śaṅkūnnihatyārdhaprādeśena taṃ*[54] *parilikhet śrutisāmarthyāt* / (7.4) /

7.3 *vyāyāmamātrī bhavatīti gārhapatyacitervijñāyate* / (7.5) / *caturaśretyekeṣām* / *parimaṇḍaletyekeṣām* / (7.6) /

7.4 *karaṇaṃ vyāyāmasya tṛtīyāyāmaṃ saptama*[55]*vyāsaṃ kārayet* / (7.7) / *tā ekaviṃśatirbhavanti* / (7.8) / *prāgāyāmāḥ prathame prastāre' parasminnudagāyāmāḥ* / (7.9) /

7.5 *maṇḍalāyāṃ mṛdo dehaṃ kṛtvā madhye śaṅkuṃ nihatyārdhavyāyāmena saha maṇḍalaṃ parilikhet* / *tasminścaturaśramavadadhyādyāvatsaṃbhavettannavadhā vyavalikhya traidhamekaikaṃ pradhikaṃ vibhajet* / (7.10) /

7.6 *upadhāne caturaśrasyāvāntaradeśānprati sraktīssaṃpādayet* / *madhyānītarasmin*[56]*prastāre* / *vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (7.11) /

7.7 *piśīlamātrā bhavantīti dhiṣṇyānāṃ*[57] *vijñāyate* / (7.12) / *caturaśrā ityekeṣām* / *parimaṇḍalā ityekeṣām* / (7.13) /

7.8 *mṛdo dehānkṛtvā āgnīdhrīyaṃ navadhā vyavalikhya ekasyāssthāne'*[58] *śmānamupadadhyāt* / (7.14) / *yathāsaṃkhyamitarān*[59] *vyavalikhya yathāyogamupadadhyāt* / (7.15) /

8

8.1 *bhavatīva khalu vā eṣa*[60] *yo'gniṃ cinuta*[61] *iti vijñāyate* / *vayasāṃ vā eṣa pratimayā cīyata ityākṛticodanā*[62] *pratyakṣavidhānādvā* /

8.2 *yāvadāmnātena*[63] *veṇunā catura*[63] *ātmani puruṣānavamimīte* / *puruṣaṃ dakṣiṇe pakṣe puruṣaṃ pucche puruṣamuttare* / *aratninā dakṣiṇato dakṣiṇaṃ*

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[53] *-pañcakai*, D; *-pañcamī*, Gr. ; *-pañcame*, S.
[54] Repeated in MU, BK.
[55] *saptavyāsaṃ*, D.
[56] *-nitasmin-*. D.
[57] *dhiṣṇiyānāṃ*, BK.
[58] *-syā*, S; *-sya*, Gr.
[59] *-itarā*, MU.
[60] Not in D
[61] *cinute*, MU.
[62] *codonāt*, MU, Gr.
[63] *āmnānena*, MU, Gr.
[63] *caturaśre*, MU.

pakṣaṃ vardhayati[64] / *evamuttarata uttaram* / *prādeśena vitastyā vā paścāt puccham* /

8.3 *ekavidhaḥ prathamo' gnirdvividhaḥ dvitīyastrividhastṛtīyaḥ* / *ta evameva ādyantyaikaśatavidhāt* /

8.4 *tadu ha vai saptavidhameva cinvīta* / *saptavidho vāva prākṛto'gniḥ* / *tata ūrdhvamekottarāniti vijñāyate* /

8.5 *ekavidhaprabhṛtīnāṃ na pakṣapucchāni bhavanti* / *saptavidhavākyaśeṣatvācchrutivipratiṣedhācca* /

8.6 *aṣṭavidhaprabhṛtīnāṃ yadanyatsaptabhyastatsaptadhā vibhajya pratipuruṣamāveśayet* / *ākṛtivikārasyāśrutatvāt* /

8.7 *puruṣamātreṇa vimimīte veṇunā vimimīte iti vijñāyate* /

9

9.1 *yāvānyajamāna ūrdhvabāhustāvadantarāle venośchidre karoti madhye tṛtīyam* / *apareṇa yūpāvaṭadeśamanupṛṣṭhyaṃ veṇuṃ nidhāya chidreṣu śaṅkūn*[65]*nihatya unmucyāparābhyāṃ dakṣiṇāprākparilikhed*[66] *antāt* / *unmucya pūrvasmādaparasmin*[67]*pratimucya dakṣiṇā pratyakparilikhedantāt*[66] / (8.8) / *unmucya veṇuṃ madhyame śaṅkāvantyaṃ veṇośchidraṃ pratimucyoparyuparilekhāsamaraṃ dakṣiṇā veṇuṃ nidhāyāntye chidre śaṅkuṃ nihatya tasminmadhyamaṃ veṇośchidraṃ pratimucya*[68] *lekhāntayoritare pratiṣṭhāpya chidrayośśaṅkū nihanti* / *sa*[69] *puruṣaścaturaśraḥ* / (9.1) /

9.2 *evaṃ pradakṣiṇaṃ catura*[70] *ātmani puruṣānavamimīte* / *puruṣaṃ dakṣiṇe pakṣe puruṣaṃ pucche puruṣamuttare* / *aratninā dakṣiṇato*[71] *dakṣiṇamityuktam* /

9.3 *pṛṣṭhyāto vā puruṣamātrasyākṣṇayā veṇuṃ nidhāya pūrvasminnitaram* / *tābhyāṃ dakṣiṇaṃ aṃsaṃ nirharet* / *viparyasya śroṇī* / *pūrvavaduttaramaṃsam* /

9.4 *rajjvā vā vimāyottaravedinyāyena veṇunā vimimīte*[72] /

9.5 *sapakṣapuccheṣu vidhābhyāse' pacaye ca vidhāsaptamakaraṇīṃ puruṣasthānīyāṃ kṛtvā viharet* /

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[64] *pravardhayati*, BK.

[65] *śaṅkuṃ*, S, Gr.

[66] *āntāt*, MU.

[67] *aparasmin*, not in D.

[68] Not in Gr.

[69] Not in Gr.

[70] *caturasra*, D, Gr.

[71] Not in D.

[72] *mimīte*, Gr.

9.6 *karaṇānīṣṭakānāṃ puruṣasya pañcamena kārayet | tāsāmevaikato' dhyardhāstaddvitīyam | paruṣasya pañcamo bhāga ekataḥ prādeśa ekataḥ tattṛtīyam | sarvataḥ prādeśastaccaturtham | samacaturaśrāḥ pañcadaśabhāgīyāstatpañcamam |*

9.7 *ūrdhvapramāṇamiṣṭakānāṃ jānoḥ pañcamena kārayedardhena nākasadāṃ pañcacoḍānāṃ*[73]*ca |*

9.8 *yatpacyamānānāṃ pratihraseta*[74] *purīṣeṇa tatsaṃpūrayedaniyataparimāṇatvāt purīṣasya |*

10

10.1 *upadhāne' dhyardhā daśa purastāt pratīcīrātmanyupadadhāti | daśa paścātprācīḥ | pañca pañca pakṣāgrayoḥ | pakṣāpyayayośca viśayāḥ tāsāmardheṣṭakāmātrāṇi pakṣayorbhavanti | pañca pañca*[75] *pucchaparśvayordakṣiṇā | udīcīśca |*

10.2 *pucche prādeśamupadhāya sarvamagniṃ pañcamabhāgīyābhiḥ pracchādayet |*

10.3 *pañcadaśabhāgīyābhiḥ saṃkhyāṃ pūrayet |*

10.4 *aparasminprastāre' dhyardhā daśa dakṣiṇata udīcīrātmanyupadadhāti | daśottarato dakṣiṇā | yathā prathame prastāre pakṣau tathā puccham | yathā pucchaṃ tathā pakṣau | viparītā apyaye |*

10.5 *sarvamagniṃ pañcamabhāgīyābhiḥ pracchādayet |*

10.6 *pañcadaśabhāgīyābhiḥ saṃkhyāṃ pūrayet | vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet |*

10.7 *pañca citayo bhavanti | pañcabhiḥ purīṣairabhyūhatīti purīṣāntā citiḥ arthāntaratvātpurīṣasya |*

10.8 *jānudaghnaṃ*[76] *sāhasraṃ*[77] *cinvīta prathamaṃ cinvānaḥ | nābhidaghnaṃ*[76] *dviṣāhasraṃ dvitīyamāsyadaghnaṃ triṣāhasraṃ tṛtīyamuttaramuttaraṃ jyāyāṃsam | mahāntaṃ bṛhantamaparimitaṃ svargakāmaścinvīteti vijñāyate |*

10.9 *dviṣāhasre dviprastārāścitayo bhavanti | triṣāhasra triprastārāścaturthaprabhṛtiṣvāhāreṣu nityamiṣṭakāparimāṇam |*

10.10 *vijñāyate ca na jyāyāṃsaṃ citvā kanīyāṃsaṃ cinvīteti*[78] *|*

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[73] *pañcacūḍānāṃ*, MU.
[74] *pratihrasīta*, MU ; *pratihraset*, D.
[75] Once in S.
[76] *-daghnīṃ*, MU.
[77] Missed in D.
[78] This whole line not in Gr.

11

11.1 *caturaśrābhiragniṃ cinuta*[79] *iti vijñāyate / samacaturaśrā anupa*[80]*-padatvācchabdasya /*

11.2 *pādamātryo bhavanti aratnimātryo bhavantyūrvasthimātryo bhavantyaṇūkamātryo bhavantīti vijñāyate /*

11.3 *caturbhāgīyamaṇūkam / pañcama*[81]*bhāgīyāratniḥ / tathorvasthi /*

11.4 *pādeṣṭakā pādamātrī / tatra yathākāmī śabdārthasya viśayitvāt /*

11.5 *upadhāne' ṣṭāvaṣṭau pādeṣṭakāścaturbhāgīyānāṃ pakṣāgrayornidadhyāt / sandhyośca tadvadātmānaṃ ṣaḍaṅgulāvetāḥ*[82] */ śroṇyaṃseṣu cāṣṭau prācīḥ pratīcīśca /*

11.6 *sandhyantarāle pañcabhāgīyāssapādāḥ*[83] */*

11.7 *pucche prādeśamupadhāya sarvamagniṃ caturbhāgīyābhiḥ pracchādayet /*

11.8 *pādeṣṭakābhiḥ saṃkhyāṃ pūrayet /*

11.9 *aparasminprastāre pucchāpyaye pañcamabhāgīyā*[81] *viśayāḥ / tā ātmani caturdaśabhiḥ pādairyathāyogaṃ upadadhyāt*[84] */*

11.10 *sarvamagniṃ pañcamabhāgīyābhiḥ*[81] *pracchādayet /*

11.11 *pādeṣṭakābhiḥ saṃkhyāṃ pūrayet / vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet /*

12

12.1 *ekavidhaprabhṛtīnāṃ karaṇīnāṃ dvādaśena trayodaśenetīṣṭakāḥ kārayet / pādeṣṭakāśca / vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet /*

12.2 *ekavidhaprabhṛtīnāṃ prathamāhāreṇa dvitīyena tṛtīyeneti yoyujyeta / sarveṣāṃ yathā śrutisaṃkhyā tathordhvapramāṇam /*

12.3 *kāmyā guṇavikārāḥ guṇaśāstratvāt /*

12.4 *praugaṃ*[85] *cinvīta bhrātṛvyavāniti vijñāyate /*

12.5 *yāvānagniḥ sāratniprādeśo dvistāvatīṃ bhūmiṃ caturaśrāṃ kṛtvā pūrvasyāḥ karaṇyā ardhācchroṇī*[86] *pratyālikhet / sā nityā praugam /*

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[79] *cinvīte*, D.

[80] *anupadatvāc*, D.

[81] *pañcabhāgīyāḥ*, D.

[82] *ṣaḍaṅgulopetāḥ*, BK.

[83] Only *pādāḥ*, D.

[84] *paryupa-* BK.

[85] *praugacitaṃ* BK.

[86] *-chroṇīṃ* MU.

12.6 *karaṇāni cayanamityekavidhoktam / praugā iṣṭakāḥ kārayet /*

12.7 *ubhayataḥ praugaṃ cinvīta yaḥ kāmayeta prajātān bhrātṛvyānnudeya pratijaniṣyamāṇāniti vijñāyate /*

12.8 *yathā vimukhe śakaṭe /* (12.8) / *tāvadeva dīrghacaturaśraṃ*[87] *vihṛtya pūrvāparayoḥ karaṇyorardhāttāvati dakṣiṇottarayornipātayet / sā*[88] *nityobhayataḥ praugam /* (12.9) / *praugacitoktam /* (12.10) /

12.9 *rathacakracitaṃ cinvīta bhrātṛvyavāniti vijñāyate /* (12.11) /

12.10 *yāvānagniḥ sāratniprādeśastāvatīṃ bhūmiṃ parimaṇḍalāṃ kṛtvā tasmiṃścaturaśram*[89]*avadadhyādyāvatsaṃbhavet /* (12.12) /

13

13.1 *tasya karaṇyā dvādaśeneṣṭakāḥ kārayet /*

13.2 *tāsāṃ ṣaṭpradhā*[90]*vupadhāya śeṣamaṣṭadhā vibhajet /*

13.3 *upadhāne caturaśrasyāvāntaradeśān pratisraktīssaṃpādayet / madhyānītarasmin prastāre / vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet /*

13.4 *droṇacitaṃ cinvītānnakāma iti vijñāyate /*

13.5 *dvayāni tu khalu droṇāni caturaśrāṇi parimaṇḍalāni ca /*

13.6 *tatra yathākāmī śabdārthyasya viśayitvāt /*

13.7 *caturaśraṃ vā yasya guṇaśāstram /* (13.7) / *sa caturaśraḥ /* (13.8) /

13.8 *paścāttsarurbhavatyanurūpatvāyeti vijñāyate /* (13.9) /

13.9 *sarvasyā bhūmerdaśamaṃ tsaruḥ / tasya pucchena nirhāra uktaḥ /* (13.10) /

13.10 *tasya karaṇyā dvādaśeneṣṭakāḥ kārayedadhyardhāḥ pādeṣṭakāśca /* (13.11) /

13.11 *upadhāne' dhyardhāḥ purastātpratīcīrātmanyupadadhāti / tsarvagre śroṇyośca prācīḥ /* (13.12) /

13.12 *sarvamagniṃ caturaśrābhiḥ pracchādayet /* (13.13) /

13.13 *pādeṣṭakābhiḥ saṃkhyāṃ pūrayet /* (13.14) /

13.14 *aparasminprastāre' dhyardhā dakṣiṇata udīcīrātmanyupadadhātyuttarataśca dakṣiṇāḥ / tsarupārśvayordakṣiṇā udīcīśca /* (13.15) /

13.15 *sarvamagniṃ caturaśrābhiḥ pracchādayet /* (13.16) /

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[87] *dīrghaṃ caturaśraṃ* MU.
[88] Not in MU.
[89] *-caturam-* MU.
[90] *-pradhā upadhāya* MU.

13.16 *pādeṣṭakābhiḥ saṃkhyāṃ pūrayet* / (13.17) / *vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (13.16) /

14

14.1 *samūhyaṃ cinvīta paśukāma iti vijñāyate* /

14.2 *samūhanniveṣṭakā*[91] *upadadhāti* /

14.3 *dikṣu cātvālā bhavanti* / *tebhyaḥ purīṣamabh*[92]*yuhatīti vijñāyate* /

14.4 *paricāyyaṃ cinvīta grāmakāma iti vijñāyate* /

14.5 *madhyamāṃ svayamātṛṇṇāṃ pradakṣiṇamiṣṭakāgaṇaiḥ paricinoti* / *sa paricāyyaḥ* /

14.6 *upacāyyaṃ cinvīta grāmakāma iti vijñāyate* / (14.6) / *paricāyyenoktaḥ* / (14.7) /

14.7 *śmaśānacitaṃ cinvīta yaḥ kāmayeta pitṛloka ṛdhnuyāmiti vijñāyate* / (14.8) /

14.8 *dvayāni tu*[93] *khalu śmaśānāni caturaśrāṇi parimaṇḍalāni ca* / (14.9) /

14.9 *tatra yathākāmī śabdārthasya viśayitvāt* / (14.10) /

14.10 *caturaśraṃ vā yasya guṇaśāstram* / (14.11) / *sa caturaśraḥ* / *tsaruvarjaṃ droṇacitoktaḥ* / (14.12) /

14.11 *chandaścitaṃ cinvīta paśukāma iti vijñāyate* / (14.13) /

14.12 *sarvaiśchandobhiścinuyādityekam* / *prākṛtairityaparam* / (14.14) /

15

15.1 *śyenacitaṃ cinvīta suvargakāma iti vijñāyate* /

15.2 *vakrapakṣo vyastapuccho bhavati* / *paścātprāñudūhati* / *purastātpratyañudūhati*[94] / *evamiva hi vayasāṃ madhye pakṣanirṇāmo bhavatīti vijñāyate* /

15.3 *yāvānagniḥ sāratniprādeśaḥ saptavidhaḥ saṃpadyate* / *prādeśaṃ caturthamātmanaścaturbhāgīyāścāṣṭau* / *tāsāṃ tisraḥ śiraḥ* / *itaratpakṣayorvibhajet* /

15.4 *pañcāratniḥ puruṣaḥ* / *caturaratnirvyāyāmaḥ* / *caturviṃśatyaṅgulayo' ratniḥ* / *tadardhaṃ prādeśa iti klṛptiḥ* /

15.5 *ardhadaśamā aratnayo' ṅgulayaśca caturbhāgona pakṣāyāmaḥ* /

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[91] *-eveṣṭakā* MU.

[92] *-abhyudūhatīti* MU.

[93] Not in MU.

[94] *-udūhati* not in D.

15.6 *dvipuruṣāṃ rajjumubhayataḥ pāśaṃ*[95] *karoti madhye lakṣaṇam | pakṣasyāparayoḥ koṭyorantau niyamya lakṣaṇena prācīnamāyacchedevaṃ purastāt | sa nirṇāmaḥ |* (15.6) *| etenottaraḥ pakṣo | vyākhyātaḥ |* (15.7) *|*

15.7 *ātmā dvipuruṣāyāmo' dhyardhapuruṣavyāsaḥ |* (15.8) *|*

15.8 *pucche' rdhapuruṣavyāsaṃ puruṣaṃ pratīcīnamāyacchet | tasya dakṣiṇato' nyamuttaratasca | tāvakṣṇayā vyavalikhet | yathā' rdhapuruṣo' pyayesyāt |* (15.9) *|*

15.9 *śirasyardhapuruṣeṇa caturaśraṃ kṛtvā pūrvasyāḥ karaṇyā ardhāttāvati dakṣiṇottarayor*[96] *nipātayet |* (15.10) *|*

16

16.1 *apyayān prati śroṇyaṃsānapacchindyāt | evamiva hi śyenaḥ |*

16.2 *karaṇaṃ puruṣasya pañcamāyāmaṃ ṣaṣṭhavyāsaṃ kārayedyathāyoganataṃ tatprathamam |*

16.3 *te dve prācī saṃhite | taddvitīyam |*

16.4 *prathamasya ṣaḍbhāgamaṣṭama*[97]*bhāgena vardhayet | yathāyoganataṃ*[98] *tattṛtīyam |*

16.5 *caturbhāgīyā' dhyardhā | tasyāścaturbhāgīyāmātramakṣṇayā bhindyāt*[99] *| taccaturtham |*

16.6 *caturbhāgīyārdhaṃ pañcamam |*

16.7 *tasyākṣṇayā bhedaḥ ṣaṣṭham |*

16.8 *puruṣasya pañcama*[100]*bhāgaṃ daśabhāgavyāsaṃ pratīcīnamāyacchet | tasya dakṣiṇato' nyamuttaratasca | tāvakṣṇayā dakṣiṇāparayoḥ*[101] *koṭyorālikhet | tatsaptamam |*

16.9 *evamanyat | uttaraṃ tūttarasyāḥ koṭyālikhet tadaṣṭamam |*

16.10 *caturbhāgīyākṣṇayobhayato bhedo navamam |*

16.11 *upadhāne ṣaṣṭiḥ ṣaṣṭiḥ pakṣayoḥ prathamā udīcīrupadadhyāt*[102] *|*

16.12 *pucchapārśvayoraṣṭāvaṣṭau ṣaṣṭhyayastisro'gre tata ekāṃ tatastisraḥ tata ekām |*

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[95] *pāśāṃ* MU.
[96] *dakṣiṇayor-* MU.
[97] *-aṣṭabhāgena* MU.
[98] *-natena* BK.
[99] *chindyāt* MU.
[100] *pañcabhāgaṃ,* D.
[101] *dakṣiṇāvarayoḥ,* MU.
[102] *-nirupadadhyāt,* D, MU.

16.13 *pucchāpyaye caturthyau viśaye | tayośca*[103] *paścātpañcamyāvanīkasaṃhite |*

17

17.1 *śeṣe daśa caturthyaḥ śroṇyaṃseṣu cāṣṭau prācīḥ pratīcīśca |*
17.2 *śeṣe ca ṣaḍviṃśatiraṣṭau ṣaṣṭhyaścatasraḥ pañcamyaḥ |*
17.3 *śirasi caturthyau viśaye | tayośca purastātprācyau |*
17.4 *eṣa dviśataḥ prastāraḥ |*
17.5 *aparasminprastāre pañca pañca nirṇāmayordvitīyāḥ | apyayayośca tṛtīyā ātmānamaṣṭabhāgāvetāḥ*[104] *| śeṣe pañcacatvāriṃśat*[105]*prathamāḥ prācīḥ |*
17.6 *pucchapārśvayoḥ pañca pañca saptamyaḥ | dvitīyacaturthyoścānyatarataḥ pratisaṃhitāmekaikām | śeṣe trayodaśāṣṭamyaḥ*[106] *|*
17.7 *śroṇyaṃseṣu cāṣṭau caturthyo dakṣiṇā udīcīśca | śeṣe ca viṃśatistriṃśat ṣaṣṭhya ekaṃ pañcamīm |*
17.8 *śirasi caturthyau tayośca purastāccatasro navamyaḥ |*
17.9 *eṣa dviśataprastāraḥ |*
17.10 *vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet |*

18

18.1 *śyenacitaṃ cinvīta suvargakāma iti vijñāyate |*
18.2 *vakrapakṣo vyastapuccho bhavati | paścātprāñudūhati | purastātpratyañudūhati | evamivahi vayasāṃ madhye pakṣanirṇāmo bhavatīti vijñāyate |*
18.3 *puruṣasya ṣoḍaśībhirviṃśaśataṃ*[107] *sāratniprādeśaḥ saptavidhaḥ sampadyate | tāsāṃ catvāriṃśadātmani tisraḥ śirasi pañcadaśa pucche ekatriṃśaddakṣiṇe pakṣe tathottare |*
18.4 *adhyardhapuruṣastiryagdvāvāyāmata iti dīrgha*[108]*caturaśraṃ vihṛtya śroṇyaṃsebhyo dve dve ṣoḍaśyau nirasyet*[109] *| catvāriṃśatpariśiṣyante | sa ātmā |*
18.5 *śirasyardhapuruṣeṇa caturaśraṃ kṛtvā pūrvasyāḥ karaṇyā ardhāttāvati dakṣiṇottarayornipātayet | tisraḥ pariśiṣyante tacchiraḥ |*
18.6 *puruṣastiryagdvāvāyāmataḥ ṣoḍaśabhāgaśca dakṣinaḥ pakṣaḥ | tathottaraḥ |*
18.7 *pakṣāgre*[110] *puruṣacaturthena catvāri caturaśrāṇi kṛtvā tānyakṣṇayā vyavalikhyārdhāni nirasyet | ekatriṃśatpariśiṣyante |*

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[103] *tayostu*, MU.
[104] *-bhāgopetāḥ*, BK.
[105] Repeated in BK.
[106] This is followed by *pucchadeśe trayodaśāṣṭamyaśśerate* in MU, which appears to be part of the commentary.
[107] *ṣoḍaśabhirviṃśaṃ*, MU.
[108] *dīrghaṃ*, MU.
[109] *vidṛsyet*, D.
[110] Repeated in BK, D.

18.8 *pakṣāgramutsṛjya madhye pakṣasya prācīṃ lekhāmālikhet / pakṣāpyaye puruṣaṃ niyamya puruṣānte nitodaṃ kuryāt / nitodātprācīnaṃ puruṣānte*[111] *nitodaṃ nitodayornānāntāvālikhet / tatpakṣa*[112]*namanam / etenottaraḥ pakṣo vyākhyātaḥ /*

19

19.1 *dvipuruṣaṃ paścādardhapuruṣaṃ purastāccaturbhāgonaḥ puruṣa āyāmo' ṣṭādaśakaraṇyau pārśvayostāḥ pañcadaśa parigṛhṇanti / tatpuccham /*

19.2 *ṣoḍaśīṃ caturbhiḥ parigṛhṇīyāt / aṣṭamena tribhiraṣṭamaiścaturthena caturthasaviśeṣeneti /*

19.3 *ardheṣṭakāṃ tribhirdvābhyāṃ caturthābhyāṃ*[113] *catūrthasaviśeṣeṇeti /*

19.4 *pādeṣṭakāṃ tribhiścaturthenaikaṃ caturthasaviśeṣārdhābhyāṃ ceti /*

19.5 *pakṣeṣṭakāṃ caturbhirdvābhyāṃ caturthābhyāṃ saptamābhyāṃ*[114] *ceti /*

19.6 *pakṣamadhyīyāṃ caturbhirdvābhyāṃ caturthābhyāṃ dvisaptamābhyāṃ ceti /*

19.7 *pakṣāgrīyāṃ tribhiścaturthenaikaṃ caturthasaptamābhyāmekaṃ caturthasaviśeṣasaptamābhyāṃ ceti /*

19.8 *pakṣakaraṇyāḥ saptamaṃ tiryaṅmānī puruṣacaturthaṃ ca* [115]*pārśvamānī / tasyākṣṇayārajjvā karaṇaṃ prajṛmbhayet*[116]*/ pakṣanamanyāḥ saptamena phalakāni namayet /*

19.9 *upadhāne catasraḥ pādeṣṭakāḥ purastācchirasi / apareṇa śiraso'pyayaṃ pañca / pūrveṇa pakṣāpyayāvekādaśa / apareṇaikādaśa pūrveṇa pucchāpyayaṃ pañcāpareṇa pañca*[117] *pañcadaśa pucchāgre /*

20

20.1 *catasraścatasraḥ pakṣāgrīyāḥ pakṣāgrayoḥ paksāpyayayośca viśayāḥ /*

20.2 *tā ātmani catasṛbhiścatasṛbhiḥ ṣoḍaśībhiryathāyogaṃ paryupadadhyāt*[118] */*

20.3 *catasraścatasraḥ pakṣamadhyīyāḥ pakṣa madhyayoḥ* / (20.3) / *pakṣeṣṭakābhiḥ prācībhiḥ pakṣau pracchādayet* / (20.4) /

20.4 *avaśiṣṭaṃ ṣoḍaśībhiḥ pracchādayet / antyā bāhyaviśeṣā anyatra śirasaḥ /* (20.5) /

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[111] Not in D.

[112] *-pakṣi-*, MU.

[113] Not in D.

[114] *saptabhyāṃ*, S, D.

[115] Not in MU.

[116] *prajambhayet*, MU.

[117] Not in S.

[118] *upadadhyāt*, S.

20.5 *aparasminprastāre purastācchirasi dve ṣoḍaśyau bāhyaviśeṣe upadadhyāt* / *te'pareṇa dve viśaye abhyantaraviśeṣe* / (20.6) /

20.6 *dvābhyāmardheṣṭakābhyāṃ yathāyogaṃ paryupadadhyāt* / *bāhyaviśeṣābhyāṃ parigṛhṇīyāt* / (20.7) /

20.7 *ātma*[119] *karaṇīnāṃ sandhiṣu ṣoḍaśyo bāhyaviśeṣā upadadhyāt* / (20.8) /

20.8 *catasraścatasro' rdheṣṭakāḥ pakṣāgrayoḥ* / *pakṣeṣṭakābhirudīcībhiḥ pakṣau pracchādayet* / (20.9) /

20.9 *tisrastisro' rdheṣṭakāḥ pucchapārśvayoḥ* / (20.10) /

20.10 *avaśiṣṭaṃ ṣoḍaśībhiḥ pracchādayet* / *antyā bāhyaviśeṣā anyatra pucchāt* / (20.11) /

20.11 *yaccaturaśraṃ tryaśraṃ*[120] *vā saṃpadyetārdheṣṭakābhiḥ pādeṣṭakābhirvā pracchādayet* / (20.12) / *aṇukāḥ pañcadaśabhāgīyānāṃ sthāne* / (20.13) /

20.12 *vyatyāsaṃ cinuyādyāvataḥ prastārāṃścikīrṣet* / (20.14) /

21

21.1 *kaṅkacidalajaciditi śyenacitā*[121] *vyākhyātau* /

21.2 *evamiva hi śyenasya varṣīyāṃsau pakṣau pucchādvakrau saṃnataṃ puccham dīrgha ātmā' maṇḍalaḥ śiraśca* / *tasmācchrutisāmarthyāt* / *aśirasko vā' nāmnānāt* /

21.3 *vijñāyate*[122] *ca* / *kaṅkacitaṃ śīrṣaṇvantaṃ cinvīta yaḥ kāmayeta saśīrṣo' muṣmiṃlloke saṃbha*[123]*veyamiti vidyamāne kathaṃ brūyāt* /

21.4 *prākṛtau vakrau pakṣau saṃnataṃ pucchaṃ vikāraśravaṇādyathāprakṛtyātmā' vikārāt*[124] /

21.5 *yatho*[125] *etacchyenacitaṃ cinvīteti yāvadāmnātaṃ*[126] *sārūpyaṃ tadvyākhyātam* /

21.6 *tristāvo' gnirbhavatītyaśvamedhe vijñāyate* /

21.7 *tatra sarvābhyāso' viśeṣāt* /

21.8 *dīrghacaturaśrāṇāṃ samāsena pakṣapucchānāṃ samāsa uktaḥ* /

21.9 *ekaviṃśo' gnirbhavatītyaśvamedhe vijñāyate* /

21.10 *tatra puruṣābhyāso nāratniprādeśānāṃ saṃkhyāsaṃyogāt saṃkhyāsaṃyogāt* /

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[119] *ātmanaḥ karaṇīnāṃ*, MU.

[120] *tryaśri*, D.

[121] *-cityā*, D.

[122] Not in D; *jñāyate*, MU.

[123] *bhaveyam-*, S.

[124] *-'vikārāśravaṇāt*, S.

[125] *atho*, MU.

[126] *āmnānaṃ*, S; *āmnānasārūpyaṃ*, MU.

KĀTYĀYANA-ŚULBASŪTRA

1

1.1 *rajjusamāsaṃ vakṣyāmaḥ* |

1.2 *same śaṅkuṃ nikhāya śaṅkusammitayā rajjvā maṇḍalaṃ parilikhya yatra lekhayoḥ śaṅkvagracchāyā nipatati tatra śaṅkū*[1] *nihanti sā prācī* | *tadantaraṃ rajjvābhyasya pāśau kṛtvā śaṅkvoḥ pāśau pratimucya dakṣiṇāyamya madhye śaṅku*[2]*mevamuttarataḥ sodīcī* |

1.3 *rajjvantayoḥ pāśau karoti* | *śroṇyaṃsanirañchanasaṃkhyāsamāsabhaṅgeṣu lakṣaṇāni* | *prācyantayoḥ śaṅkū nihanti* | *śroṇyoraṃsayośca*[3] | *śaṅkvoḥ pāśau pratimucya nirañchanena gṛhītvā dakṣiṇapūrvāṃ diśaṃ haranti* | *evamuttarataḥ* | *viparyasyetarataḥ* | *sa samādhiḥ sarvatra* |

1.4 *pramāṇamabhyasyābhyāsacaturthe lakṣṇaṃ karoti tannirañchanam* | *akṣṇayā tiryaṅmānīśeṣa* |

1.5 *pramāṇārdhaṃ vābhyasyābhyāsaṣaṣṭhe*[4] *lakṣaṇaṃ karoti tannirañchanam* | *akṣṇayā tiryaṅmāniśeṣaḥ* |

1.6 *pramāṇārdhe samacaturaśrasya śaṅkuḥ* | *śāstravadardhe dīrghacaturaś-rasya* | *śakaṭamukhasya caivam* |

1.7 *etena prāgvaṃśavedimānāni vyākhyātāni* | *śālāmānaṃ ca* | *tatrodīcī prācīvat* | *sadasaścaivam* |

1.8 *aparimitaṃ pramāṇādbhūyaḥ* |

1.9 *pramāṇe śāstraṃ pramāṇaṃ nirhāsavivṛddhyoḥ*[5] | *yogaśca* |

1.10 *itarasyavitṛtīye dakṣiṇata ityetadvakṣyāmaḥ* | *gārhapatyāhavanīyayoran-tarālaṃ ṣaḍhdhā saptadhā vāgantusamaṃ tredhā vibhajyāparavitṛtīyalakṣa-ṇena dakṣiṇāyamya tasminnagniḥ* | *viparyasyottarata utkaraḥ* |

1.11 *apivāntaratribhāgo' nayā rajjvā purvārdhe samacaturaśraṃ kṛtvā śroṇ-yāmagniḥ* | *viparyasyottarāṃsa utkaraḥ* |

2

2.1 *aṅgulai rathasaṃmitāyāḥ pramāṇam* | *tatrāṣṭāśītiśatamīṣā* | *catuḥśata-makṣaḥ* | *ṣaḍaśītiryugam* | *catvāro' ṣṭakāḥ śamyā* |

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[1] *śaṅkuṃ*, P.
[2] *śaṅkurevam*, P.
[3] *śroṇyaṃsayo*, P.
[4] *vābhyāsaṣaṣṭhe*, P.
[5] *-vivṛdhyoḥ*, K.

producers of the *śulba*-texts. Baudhāyana and Āpastamba whose *śulbasūtras* are fully discussed in this book belonged to the *Taittiriya* school, the *Maitrāyaṇi* school is represented by Mānava, while we have in Kātyāyana the sole representative of the White Yajurvedins in this ancient mathematical effort. Apart from basic geometry and arithmetic we have in these works a fairly detailed glimpse of the Vedic sacrificial cult built around various types of altars designed in the likeness of birds and other familiar objects,—the falcon, the kite, the chariot wheel, the funeral pyre, and geometrical figures like isosceles triangle, rhombus and trapezium. Man's eternal craving for wish fulfilment was supposed to be achieved through sacrifices over such fire-altars aptly called the *kāmya agni*, whose philosophical importance need hardly be overestimated.

P. V. Kane placed Baudhāyana, Āpastamba and Kātyāyana between 800 B.C. and 400 B.C. Ramgopal also concluded that the principal *sūtras* by the above-mentioned *sūtrakāras* were composed between 800 B.C. and 500 B.C. These dates are discussed. But there can hardly be any doubt that what Baudhāyana, Āpastamba, Mānava, Kātyāyana and others tried to codify in a systematic manner in their *śulbasūtra* manuals must have for a long time formed the common property of all *adhvaryus* and priests specialized in the performance of sacrificial rites. The origin of mathematics in India clearly lies embedded in these ancient priestly practices.

tvā karaṇīmadhye śaṅkavaḥ sa

kṣṇayā ceti rajjavaḥ |
syākṣṇyā rajjurdaśakaraṇī |
mānī tasyākṣṇayā rajjuścatvār-

ṃ ca darśanāt |
īnī pārśvamānī ca yatpṛthag-
|

enātmacatustriṃśonena saviśeṣa

ṣṇayā rajjustrikaraṇī |
hāgastu navadhā karaṇītṛtīyaṃ

aṇī samāsārthā |
taḥ samāsaḥ | nānāpramāṇa-
hindyāttasyākṣṇayā rajjurubhe

jihīrṣettāvadubhayato' pacchidya
sammitāmakṣṇayāṃ tatropasaṃ-
hrāsaḥ |
n madhye tiryagapacchidyānyata-
ccheṣamāgantunā purayettasyokto

dyaikasamāsena samasya śeṣaṃ

ṣan madhye' kṣṇayā' pacchidya
dhyādviṣamaṃ cedyathāyogamu-

avakaraṇī catuḥpramāṇā ṣoḍa-

nto vargā bhavanti tānsamasyet |

2.2 *paitṛkyāṃ dvipuruṣaṃ samacaturaśraṃ kṛtvā karaṇīmadhye śaṅkavaḥ sa samādhiḥ* |

2.3 *karaṇī tatkaraṇī tiryaṅmānī pārśvamānyakṣṇayā ceti rajjavaḥ* |

2.4 *padaṃ tiryaṅmānī tripadā pārśvamānī tasyākṣṇyā rajjurdaśakaraṇī* |

2.5 *evaṃ dvipadā tiryaṅmānī ṣaṭpadā pārśvamānī tasyākṣṇayā rajjuścatvāriṃśatkaraṇī* |

2.6 *upadiṣṭaṃ yugapramāṇaṃ śamyāpramāṇaṃ ca darśanāt* |

2.7 *dīrgha*[6]*caturaśrasyākṣṇayā rajjustiryaṅmānī pārśvamānī ca yatpṛthagbhūte kurutastadubhayaṃ karotīti kṣetrajñānam* |

2.8 *samacaturaśrasyākṣṇayā rajjurdvikaraṇī* |

2.9 *karaṇīṃ tṛtīyena vardhayettacca svacaturthenātmacatustriṃśonena saviśeṣa iti viśeṣaḥ*[7] |

2.10 *pramāṇaṃ tiryak dvikaraṇyāyāmastasyākṣṇayā rajjustrikaraṇī* |

2.11 *tṛtīyakaraṇyetena vyākhyātā* | *pramāṇavibhāgastu navadhā karaṇītṛtīyaṃ navabhāgaḥ* | *navabhāgāstrayastṛtīyakaraṇī* |

2.12 *sautrāmaṇyāṃ prakramārthā* | *tṛtīyakaraṇī samāsārthā* |

2.13 *tulyapramāṇānāṃ samacaturasrāṇāmuktaḥ samāsaḥ* | *nānāpramāṇasamāse hrasīyasaḥ karaṇyā varṣīyaso'pacchindyāttasyākṣṇayā rajjurubhe samasyatīti samāsaḥ* |

3

3.1 *caturaśrāccaturaśraṃ nirjihīrṣan yāvannirjihīrṣettāvadubhayato' pacchidya śaṅkū*[8] *nikhāya pārśvamānīṃ kṛtvā pārśvamānīsammitāmakṣṇayāṃ tatropasaṃharati, sa samāse' pacchedaḥ, sā karaṇyeṣa nirhrāsaḥ* |

3.2 *dīrghacaturaśraṃ samacaturaśraṃ cikīrṣan madhye tiryagapacchidyānyataradvibhajyetaratpurastāddakṣiṇataścopadadhyāccheṣamāgantunā purayettasyokto nirhrāsaḥ* |

3.3 *atidīrghaṃ cettiryaṅmānyāpacchidyāpacchidyaikasamāsena samasya śeṣaṃ yathāyogamupasaṃharedityekaḥ samāsaḥ* |

3.4 *samacaturaśraṃ dīrghacaturaśraṃ*[9] *cikīrṣan madhye' kṣṇayā' pacchidya tacca vibhajyānyataratpurastāduttarataścopadadhyādviṣamaṃ cedyathāyogamupasaṃharediti vyāsaḥ* |

3.5 *pramāṇaṃ caturaśramādeśādanyat* |

3.6 *dvipramāṇā catuḥkaraṇī tripramāṇa navakaraṇī catuḥpramāṇā ṣoḍaśakaraṇī* |

3.7 *yāvatpramāṇā rajjurbhavati tāvantastāvanto vargā bhavanti tānsamasyet* |

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[6] *caturasrasyākṣṇayā*, P.

[7] *iti viśeṣaḥ*, P omits.

[8] *śaṅkuṃ*, P.

[9] P omits.

3.8 *ardhapramāṇena pādapramāṇaṃ vidhīyate / tṛtīyena navamo' ṃśaḥ / caturthena*[10]*ṣoḍaśī kalā /*

3.9 *eṣa nirhrāsastasya purastāduktaṃ śāstram /*

3.10 *yāvatpramāṇā rajjurbhavatīti vivṛddhe hrāso bhavati /*

3.11 *caturaśraṃ maṇḍalaṃ cikīrṣanmadhyādaṃse nipātya pārśvataḥ parilikhya tatra yadatiriktaṃ bhavati tasya tṛtīyena saha maṇḍalaṃ parilikhet sa samādhiḥ /*

3.12 *maṇḍalaṃ caturaśraṃ cikīrṣan viṣkambhaṃ pañcadaśabhāgān kṛtvā dvāvuddharecccheṣaḥ karaṇī /*

4

4.1 *droṇacidrathacakracitkaṅkacitpraugacidubhayataḥ praugaḥ samuhya-purīṣa ityagnayaḥ /*

4.2 *droṇe yāvānagniḥ sapakṣapucchaviśeṣastāvaccaturaśraṃ kṛtvā droṇadaśa-mavibhāgo vṛnt*[11]*amityeke / taddaśamenāpacchidyāpacchidyaikasamāsena samasya nirhṛtya sarvamagniṃ tathākṛtiṃ kṛtvā purastātpaścādvopadadhyāt/ maṇḍale' pyevam /*

4.3 *prauge yāvānagniḥ sapakṣapucchaviśeṣastāvaddviguṇaṃ caturaśraṃ kṛtvā yaḥ purastātkaraṇīmadhye śaṅkuryau ca śroṇyoḥ so 'gniḥ /*

4.4 *ubhayataḥ prauge tāvadeva dīrghacaturaśraṃ kṛtvā karaṇīmadhyeṣu*[12] *śaṅkavaḥ sa samādhiḥ /*

4.5 *praugaṃ caturaśraṃ cikīrṣanmadhye prāñcamapacchidya viparyasye*[13]*tarata upadhāya dīrghacaturaśrasamāsena samasyet sa samādhiḥ /*

4.6 *ubhayataḥ praugaṃ cenmadhye tiryagapacchidya pūrvavatsamasyet /*

4.7 *etenaiva trikarṇasamāso vyākhyātaḥ / pañcakarṇānāṃ ca / prauge' pacchi-dyaikakarṇānāṃ*[14] */ dvikarṇānāṃ samacaturaśre 'pacchidya*[15] */*

5

5.1 *uttareṣu puruṣoccayenaikaśatavidhādityetadvakṣyāmaḥ /*

5.2 *ādyo 'gnirdviguṇastriguṇo bhavatīti sarvasamāsaḥ /*

5.3 *ekaviṃśatividho bhavatīti puruṣābhyāsaḥ*[16] */*

5.4 *puruṣābhyāse yāvānagniḥ sapakṣapucchaviśeṣastāvaccaturaśraṃ kṛtvā tas-minpuruṣapramāṇamavadadhyāt*[17] */*

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[10] *śaturthena*, P.
[11] *vṛtta*, P.
[12] *-madhye*, P.
[13] *viparyasyotarat*, P.
[14] *-ekakarṇānām*, P omits.
[15] P. omits *dvikarṇānāṃ samacaturasre' pacchidya*.
[16] *puruṣobhyāsaḥ*, P.
[17] *upadadhyāt*, P.

5.5 *samastaṃ pañcadaśabhāgānkṛtvā dvāvekasamāsena samasyet sa puruṣaḥ* |
5.6 *pañcavibhāgena bṛhatī tasya daśamavibhāgena pādamātrī bhavati*[18] |
5.7 *puruṣaṃ vā pañcamenobhayato 'pacchidya pañcavibhāgan samasya tṛtīyaṃ nirhṛtya tasmin puruṣapramāṇe 'vadadhyādityaparam* |
5.8 *pañcadaśavibhāgo 'ṣṭāṅgulam* |
5.9 *pañcāratnirdaśavitastirviṃśatiśatāṅgulaḥ puruṣa ityetasmād*[19] *dvādaśāṅgulaṃ padamiti*[20] *ca*[21] |
5.10 *puruṣaṃ vā sapta*[22]*menobhayato 'pacchidya saptabhāgān samasya sasaptamabhāgamaṅgulaṃ nirhṛtya puruṣapramāṇe 'vadadhyādityaparam* |
5.11 *nāratnivitastīnāṃ samāso vidyate saṃkhyāyogāditi śruteḥ* |

6

6.1 *yathāgni vedīṣṭakāpramāṇaṃ varddhata ityetadvakṣyāmaḥ* |
6.2 *yā karaṇī caturdaśaprakramānsaṅkṣipati triṃśca prakramasaptamabhāgān sa ekaśatavidhe prakramaḥ* |
6.3 *dvitīye vā saptasu prakrameṣu prakramamavadhāya tasya saptamabhāgena prakramārthaḥ* |
6.4 *prakrameṇa vā saptamabhāgena prakramārthaḥ*[23] |
6.5 *evam*[24]*aikaśatavidhāt* |
6.6 *nāntaḥpātyagārhapatyayorvṛddhirbhavati tāvadeva yonirbhavati na vai jātaṃ garbhaṃ yoniranuvardhata iti śrutervṛddheratyantaṃ pratiṣedhaḥ* |
6.7 *yāvatpramāṇāni samacaturaśrāṇyekīkartuṃ cikīrṣedekonāni tāni bhavanti tiryagdviguṇānyekata ekādhikāni tryasrirbhavati tasyeṣustatkaroti* |
6.8 *yathāyūpaṃ vedivarddhanamityetadvakṣyāmaḥ* |
6.9 *yā rajjurekādaśoparavān saṅkṣipati daśa ca rathākṣāṃstasyā yaścaturviṃśo bhāgaḥ sa prakramaḥ* |
6.10 *tena vediṃ nirmāya*[25] *dvādaśāṅgulaṃ purastādapacchidya tadyūpāvatyācchaṅkoḥ purastātprāñcamavadhāya tasmin yūpānminoti* |
6.11 *pārśvayorvā 'rdhamantarvedīti śruterarddhakāniti* |
6.12 *eke prathamottamau prakṛtivat* |
6.13 *saiṣā śikhaṇḍinī vediḥ*[26] |

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[18] P. omits *tasya daśamavibhāgena pādamātrī bhavati*.
[19] P. omits *ityetasmād*.
[20] P gives after *padam, puruṣamityetasmātpuruṣādvijñeyam*.
[21] P. omits *ca*.
[22] *pañcamena*, P.
[23] P. gives *ā* in place of *prakramārthaḥ*.
[24] P. omits *evam*.
[25] P. gives *mithunaṃ yāvat yad* in place of *nirmāya*.
[26] P. omits *saiṣā sikhaṇḍinī vediḥ*.

MĀNAVA-ŚULBASŪTRA

1

1.1 *athātaḥ śulbaṃ vyākhyāsyāmaḥ* |

1.2 *rajjuṃ pāśavatīṃ samāṃ nirāyatāṃ pṛṣṭhyāṃ yathārthamupakalpayet* |

1.3 *antareṇa citrāsvātī śravaṇapratiśravaṇau kṛttikāpratikṛttike tiṣyapunarvasū ca prāgdeśo'yaṃ yugamātroditayoḥ pāśāñca* |

1.4 *dārśikyāḥ śayāḥ ṣaṭṭāni*[1] *sapta saptadaśaiva tu* |
ekaṃ dve pañca tairmītvā samaraiḥ parilekhayet ||

1.5 *aṃsācchroṇau rajjvantaṃ pratiṣṭhāpya prācīm*[2]*anulikhedaṃse pratiṣṭhāpya pratīcīṃ samare rajjvantaṃ pratiṣṭhāpya śroṇeradhyaṃsādanulikhet* |

1.6 *evamuttarataḥ purastātpaścācca* |

1.7 *aratniścaturaśrastu pūrvasyāgneḥ kharo bhavet* |
rathacakrākṛtiḥ paścāccandrārdhena tu dakṣiṇe ||

1.8a *madhyāt koṭipramāṇena maṇḍalaṃ parilekhayet* |
atiriktatribhāgena sarvaṃ tu sahamaṇḍalam ||

1.8b *caturaśre' kṣṇayā rajjurmadhyataḥ saṃnipātayet* |
parilekhya[3] *tadardhenārdhamaṇḍalameva tat* ||

1.9 *gārhapatyāhavanīyāvantarā rajjuṃ nimāyāparasmiṃstṛtīye lakṣaṇam* | *madhyāt turīyamutsṛjya lakṣaṇaṃ pāśāntau samāhṛtya dakṣiṇato dakṣiṇāgnerlakṣaṇam* |

1.10 *etadeva viparyasyottarata utkarasya lakṣaṇam* |

1.11 *yāvatpramāṇā rajjuḥ syāttāvadevāgamo bhavet* |
āgamārdhe bhavecchaṅkuḥ śaṅkorardhe nirāñchanam |

1.12 *samantacaturaśrāṇi vidhireṣaḥ prakīrtitaḥ* |

2

2.1 *aṣṭāśītiḥ śatamīṣā tiryagakṣaścatuḥśatam* |
ṣaḍaśītiryugaṃ cāsya rathaścārakya uccyate ||

2.2 *īṣāyāṃ lakṣaṇaṃ mītvā ṣaṭsu navasu ca lakṣaṇe* |
tricatvāriṃśake pāśo' ṅgulānāṃ niyogataḥ ||

2.3 *eṣā vediḥ samākhyātā cārakya*[4] *rathasaṃmitā* |
aindrāgnasya paśoreṣā paśuṣvanyeṣu ṣaṭśayā ||

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[1] *ṣaṣṭāni*, N.

[2] *prācīnamu*—in L, N, ASB.

[3] *parilekhyasta*—, not in L, N, ASB.

[4] *cārakye*, ASB.

2.4 *prācyardhaḥ ṣaḍaratniḥ syādardhāratnernirāñchanam |*
ardhe śroṇī tato' rdhe' ṃsāvadhyardha iti pāśukī ||
2.5a *paśādardhaśaye śroṇī dvayoḥ pṛṣṭhyāparā dvayoḥ |*
prācyardhastu tato 'dhyardhe tato 'dhyardhe nirāñchanam ||
2.5b *ardhe 'ṃso' dhyardha evānyastato 'dhyardhe 'ṃsa uttaraḥ |*
aratnau tu tataḥ pāśo vedī mārutī vārūṇī ||
2.6 *sarvā daśaśayā rajjurmadhye cāsyā*[5] *nirāñchanam |*
prācyardhaṃ pañcame kuryāddikkuṣṭhā paitṛkī smṛtā ||
2.7 *sarvā saptaśayā rajjurmadhye cāsyā nirāñchanam |*
prācyardhaṃ pañcame kuryāddikkuṣṭhā paitṛkī smṛtā ||

3

3.1 *prāgvaṃśaṃ daśakaṃ kuryātpatnīśālāṃ catuḥśayām |*
prāgvaṃśāttriṣu vedyanto vedyantāt prakrame sadaḥ ||
3.2 *navakaṃ tu sado vidyāccatvāraḥ sadaso 'ntaram |*
catvārastrikā havirdhānamardhad[6]*aśāstadantaram ||*
3.3 *padaṃ yūpāvaṭe mītvā śeṣamauttaravedikam |*
āgnīdhraṃ ṣaḍaratnyeva ṣaṭtriṃśatprakramā rajjuḥ ||
3.4 *lakṣikā dvādaśa trikā | vedisadohavirdhānāni minotyevānupūrvaśaḥ pañcadaśakamekaviṃśakaṃ*[7] *trikamaparam | parato' parastriko dvādaśasu ca pāśada ucyate | some rajju nimānamuttamam*[8] *|*
3.5 *tripadā pārśvamānī syāttiryaṅmānī padaṃ bhavet |*
tasyākṣṇayā tu yā rajjuḥ kuryāddaśapadāṃ tayā ||
3.6 *paśādardha*[9]*caturdaśe navake tu tataḥ punaḥ |*
ardhacaturdaśaḥ pāśaḥ sadasaśchedanamuttamam[10] *||*
3.7 *nimāya rajjuṃ daśabhī rathākṣairekādaśabhiścoparabudhnamātra-istasyāścaturviṃśatibhāgadheyamekādaśinīṃ prativedimāhuḥ |*
3.8a *śikhaṇḍinī cetkartavyā vedyantāddvyardhamuddharet |*
aṣṭāṅgulaṃ tadardhaṃ syāddevya[11]*vedi prasiddhaye ||*
3.8b *taṃ prāñcaṃ tu samīkṣeta tāṃstu vidyācchikhaṇḍinīm ||*
3.9 *pañcakaṃ saptaṃ*[12] *caiva ekamekaṃ tataḥ punaḥ |*
eṣā vediḥ samākhyātā kaukilyāstvatha cārake ||

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[5] *cārasyā*, N.
[6] *ṣaṣṭha*, G., N.
[7] *pañcadaśakaviṃśakaṃ* L, N, ASB.
[8] *nimāmanuttaṃ*, N.
[9] *pādādardhaṃ caturdaśe*, G, N.
[10] *-uttaram*, G.
[11] *syāddevyo-* L., N.; *syāddeyo-*. ASB.
[12] *saptakaṃ*, N.

4

4.1 *janmanā rogahīno vā yajamāno bhavedyadi |*
katham tatra pramāṇāni prayoktavyāni kartṛbhiḥ ||

4.2 *tuṇḍaṃ puṣkaranālasya ṣaḍguṇaṃ pariveṣṭitam |*
trihāyaṇyā vatsataryā vālena samamiṣyate ||

4.3 *trayastrihāyaṇīvālāḥ sarṣapārdhaṃ vidhīyate |*
dviguṇaṃ sarṣapaṃ prāhuryavaḥ sarṣapāram ||

4.4a *aṅgulasya pramāṇaṃ tu ṣaḍyavāḥ pārśvasaṃhitāḥ |*
daśāṅgulastu prādeśo vitastirdvādaśāṅgulaḥ ||

4.4b *dvivitastiraratniḥ syādvyāyāmastu catuḥśayaḥ |*

4.5 *viṃśatiśatāṅgulataḥ puruṣaḥ svaiḥ svairaṅguliparvabhiḥ |*
atha cetprapadotthānaḥ pañcaviṃśaśato bhavet ||

4.6 *triyavaṃ kṛṣṇalaṃ vidyāt*[13] *mānaṃ vidyāt trikṛṣṇalam |*
anena kṛṣṇalapramāṇena niṣkamāhuścaturguṇam ||

4.7 *puruṣasya tṛtīyapañcamau bhāgau tatkaraṇaṃ punaściteḥ |*
tasyārdhamathāparaṃ bhavettricitikamagniciticet ||

4.8 *aṣṭāvaṣṭau saṃmitā citiraṣṭaikādaśikā*[14] *ca madhyamā |*
vyatyā[15]*savatīrupany*[16]*asedaṣṭau dvādaśa cottamā citiḥ ||*

5

5.1 *athāta uttareṣṭakaṃ vyākhyāsyāmaḥ |*

5.2 *ūrdhabāhunā yajamānena veṇuṃ vimimīte |*

5.3 *tatsamo 'nyataraḥ sāratnirdvitīyastasya puruṣe lakṣaṇamaratni vitastyoścobhayorardhapuruṣe |*

5.4 *śirasi pariśrite yūpāyāvaśiṣya śeṣamanurajju puruṣau saṃdhāya pañcāṅgyā śaṅkuṃ vinihanti tayoḥ saṃdhāvardhayośca |*

5.5 *yāvabhito madhyamaṃ śaṅkuṃ tayorveṇū nidhāya dakṣiṇataḥ puruṣasaṃnipāte todaṃ karoti |*

5.6 *madhyame śaṅkau veṇuṃ nidhāyādhyadhi todaṃ hṛtvā dakṣiṇataḥ puruṣe śaṅkuṃ nihanti |*

5.7 *pūrve śaṅkau veṇuṃ nidhāya dvitīyaṃ dakṣiṇataḥ purastātpuruṣasaṃnipāte śaṅkuṃ nihantyardhe caivaṃ paścāt |*

5.8 *etenottarārdho vyākhyātaḥ |*

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[13] *vidyāttaṃ*, G.

[14] dropped in N.

[15] *vyāyāmavali*, N.

[16] *rudanya*, N.

5.9 *dakṣiṇasya vargasya yāvabhito madhyamaṃ śaṅkuṃ tayorveṇū nidhāya dakṣiṇataḥ puruṣasaṃnipāte todaṃ karoti* |

5.10 *madhyame śaṅkau veṇuṃ nidhāyādhyapi*[17] *todaṃ hṛtvā dakṣiṇataḥ sāratnau śaṅkuṃ nihanti* |

5.11 *yaḥ sāratnistaṃ madhyamasya pūrve nidhāya dvitīyaṃ dakṣiṇataḥ purastātsāratnimardhapuruṣeṇa saṃnipātya śaṅkuṃ nihantyevaṃ paścāt* |

5.12 *etenaivottarapakṣo vyākhyātaḥ* |

5.13 *pucchaṃ* | *savitastiraratnisthāne* |

5.14 *pūrvasya purastādardhapuruṣeṇa pañcāṅgyā śiro vimimīte* |

6

6.1 *vyāyāmasyāṣṭamamekatasturīyamekata ubhayatasturīyaṃ ca te gārhapatyaciteḥ karaṇe* |

6.2 *puruṣasya daśamena bhāgena prathamaṃ caturaśraṃ karaṇaṃ kārayeddaśamamekato'rdhamekatastaddvitīyaṃ daśamamekato'dhyardhamekatastattṛtīyamubhayatasturīyaṃ taccaturtham* |

6.3 *tāsāmutsedhastriṃśatpañcamabhāgenānyatra nākasadbhya*[18]*śca cūḍābhya ṛtavyābhyo 'tha madhyamāyāṃ pañcamaṣaṣṭhībhyaśca vaiśvadevībhyastā ardhotsedhāḥ*[19] |

6.4 *purīṣamantardhāyottarāmupadadhyādgaṇasaṃsargāyāvicchedāya* |

6.5 *garteṣūpadadhyādyadanyadiṣṭakābhyaḥ* |

6.6 *tatra śloko bhavati* |

ukhāyāḥ paśuśīrṣāṇāṃ kūrmasyolūkhalasya ca |
srucoḥ[20] *kumbheṣṭakānāṃ ca caroś*[21]*caivāvaṭānkhanet* ||

6.7 *pratidiśamupadadhyādātmani madhye prācīḥ śirasi pucche pakṣayoścātmanyapyayeṣu*[22] *samaṃ vibhajyottarāmuttarāmapyayasaṃhitāṃ pūrvāparadakṣiṇottarā viṣayavacanādanyaccatasraḥ purastātpañcartavyā*[23]*bhyaḥ paścāccottarapūrve cārdhe gārhapatyasya* | *śeṣaṃ caturaśrābhiḥ* |

6.8 *etā eva dakṣiṇottarā dvitīyasyāṃ* | *śeṣaṃ caturaśrābhiḥ* |

6.9 *yathā prathamaivaṃ tṛtīyā pañcamī vā*[24] *yathā dvitīyai*[25]*vaṃ caturthe* | *tena dharmena vatyāsaṃ cinuyāt* |

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[17] *-adhyadhi*, N.

[18] *-satyaṃca*, N.

[19] *pūrvotsedhā*, N.

[20] *srucaṃ*, L, N; *sruco*, ASB.

[21] *caroścai-*, G.

[22] *-apyayeśu*, G. N.

[23] *purastātprācīrutavyā-*, L., N.

[24] *ca*, N.

[25] *caturthyai*, N.

6.10 *athetarānāgnīdhrīyādīn navanava padāni karotyekaikaṃ madhye' smānamāgnīdhrīye / catvāri catvāri turīyāṇi pratidiśaṃ hotrīye / catasro 'rdhāḥ kuṣṭhāsu brāhyaṇāchaṃsya / itareṣāṃ dve dve adhyardhe madhye prācīḥ / ṣaḍeva mārjālīye paśusrapaṇe ca /*

6.11 *viṃśatimadhyardhāḥ prācīraṃsayordadyācchroṇyoḥ pucche ca viṃśatiṃ dvādaśa dvādaśa purastātpakṣayoḥ prācīḥ paścācca pañca pañca codīcīrabhitaḥ śirasi / śeṣaṃ caturaśrābhiḥ /*

6.12 *viṃśatiṃ śroṇyaṃsapakṣeṣūdīcīrdakṣiṇatastathottarato dvitīyasyāmekādaśaikādaśābhitaḥ pucche pañca pañca prācīrabhitaḥ śirasi / śeṣaṃ caturaśrābhiḥ /*

6.13 *yathā prathamaivaṃ tṛtīyā pañcamī ca yathā dvitīyaivaṃ caturthyetena dharmeṇa vyatyāsaṃ cinuyāt /*

6.14 *trirupasatsu dve pūrvasyāṃ tisro madhyamāyāṃ ṣaṭsu yathānupūrveṇa dvādaśasu vyatyāsaṃ citipurīṣe karoti /*

6.15 *etena dharmeṇa saṃvatsarātsamaṃ vibhajya jānudaghne 'sya dviguṇaṃ triguṇamuttareṣāṃ caikāmuttarāmuddhatyābhyāyanaṃ*[26] *vardhāyātiriktā upadadhyāt /*

6.16 *mantrādyabhimarśanāntaṃ tatpuruṣasya lakṣaṇam /*

7

7.1 *darbhastambaṃ puṣkaraparṇaṃ rukmapuruṣau hiraṇyeṣṭakāṃ śarkarāṃ svayamātṛṇṇāṃ dūrveṣṭakā naivāramiti madhyaṃ (ā pañcamāśraṃ svayamātṛṇṇāyā abhitastāṃ madhyam) / tasminkumbheṣṭakā yā madhye dakṣiṇottare ca srucāvanūpamadhyeṣu śeṣāḥ / paścātsvayamātṛṇṇāyāḥ kulāyinīṃ dviyajuśca vaṃśayoḥ pārśvasaṃhite dviyajuruttare purastādretaḥsicau*[27] *dve / dakṣiṇe tasminvaṃśe dvitīyāmṛtavyāṃ ca purastāccaturthe loke retaḥsicaṃ*[28] *viśvajyotiṣaṃ maṇḍalāmṛtavyāṃ gharmeṣṭakāmaṣāḍhāṃ kūrmaṃ vṛṣabhamiti prāñcamuttare vaṃśe dakṣiṇataḥ purastātsvayamātṛṇṇāyāḥ pañca*[29] *mulūkhalamusalamuttarapūrve cokhāṃ madhye śirasāṃ*[30] *śirobhiḥ saṃhitāmupadadhāti /*

7.2 *tasyāḥ paścātpuruṣaśirasaḥ puruṣacitimupadadhāti ṣaṭtriṃśataṃ pratīcīs*[31]*trivargeṇa śroṇyām /*

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[26] *-muddhartābhyāṃnyanaṃ*, L. N.; *-muddhattābhyāṃnyanaṃ*, ASB.

[27] *-sincau*, N.

[28] *-sincam*, N.

[29] *prāñca*, G.

[30] *śirastāṃ*, N.

[31] *pratyañca*, N.

7.3 *tatra śloko bhavati* |

tisro grīvāḥ ṣaḍaṃsa[32]*yordve dve bāhvornavātmani* |
jaṅghayoru pañca paścādasmānām[33]*ekaikaṃ pāṇipādayoḥ* ||

7.4 *aṣṭavathāpasyāḥ samaṃ vibhajya vaṃśeṣu navamenavame prāṇabhṛtaḥ purastāduttare vaṃśe prathamaṃ paścāddakṣiṇe dakṣiṇataḥ pūrva uttarataḥ paścāddakṣiṇataḥ svayamātṛṇṇāyā dvitīye pañcamamanūpeṣu saṃyato navame' timātrā yathā prāṇabhṛtaḥ purastāddakṣiṇe vaṃśe prathamaṃ paścāduttare dakṣiṇataḥ paścāduttarataḥ pūrva uttarataḥ pascāddakṣiṇataḥ uttarataḥ*[34] *svayamātṛṇṇāyā dvitīye pañcamam* | *vaiśvadevyaścānūpeṣu pratidiśamuttarapūrveṣu vaṃśeṣvādyā* | *dakṣiṇottare ca saṃyānyāvapyaye tayorvaṃśayorādyāt purastādvātharvaśiraḥ* |

7.5 *samaṃ vibhajya vaṃśeṣu śiraḥ pakṣapucchāni prathameṣu vaṃśeṣu lokānvijānīyāt* |

7.6 *śirasi prathame vaṃśa uttarāmuttarāmitareṣāṃ pakṣapucchānāṃ caturthe pakṣayoḥ prācīḥ pucche*[35] *codīcīrlokeṣṭakā upadadhyāccheṣāḥ paścātsvayamātṛṇṇāyā ekaikāṃ pūrvāṃ saṃhitām* | *dakṣiṇe vaṃśe vaiśvadevyādya uttare ca purīṣādyāḥ* |

7.7 *gāyatraṃ madhye śirasi rathantaraṃ bṛhadyajñāyamiti yathāmnātam* |

8

8.1 *dvitīyāyāṃ purastātsvayamātṛṇṇāyāḥ prathamadvitīyatṛtīyeṣvṛtavyā vāyavyā apasyā iti yathāsaṃkhyam* | *tisrastisro dakṣiṇeṣu vaṃśeṣu dakṣiṇottarā dve dve uttarasyottarayornavame' bhitaḥ śeṣā yathāpasyāḥ*[36] |

8.2 *tṛtīyāyāṃ daśa dvādaśa navame' abhito* | *aṣṭame sapta purastātpaścācca samīcīrabhitaḥ svayamātṛṇṇāyā ardhotsedhā aṣṭau nānāmantrā uttamāyāṃ vā* |

8.3 *caturthyāmekaikāṃ navamenavame' bhitaḥ purastāduttarasya vaṃśasya madhye prathamāṃ vyatyāsamitarā* | *evameva spṛtaḥ purastāddakṣiṇasya vaṃśasya madhye prathamāṃ vyatyāsamitarāḥ* | *ṣaṭsaptāṣṭa*[37]*meṣu dakṣiṇato yugmāyugmā uttaratastrivargānkuryātsaptadaśa dakṣiṇataḥ pañcadaśottarataḥ* |

8.4 *pañcamyāmekaikāṃ prāṇabhṛdādhiṣu śeṣaṃ chandasāṃ virājaśca yathātimātrāḥ ṣaṭsaptāṣṭameṣvabhito yathāsaṃkhyam* |

8.5 *ardheṣṭakābhiḥ pūrayitvā dakṣiṇataḥ prācīḥ stomabhāgāḥ paścimāśca yugmā uttaratastrivargānkuryādekatriṃśatam* | *paścātpratyañcaṃ trivargeṇa*

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[32] *satśayo-* L., N.

[33] *aśmānām*, N.

[34] *paścāddakṣiṇataḥ uttarataḥ*, appears in N.

[35] *pakṣe*, N.

[36] *yathāstasyāḥ*, N.

[37] *ṣaṭsaptamāṣṭameṣṭameṣṭa*, N.

nākasadaṃ ca paścātpurīṣavatyā yavādinā sanāmnīrupaśīvarīrghṛtaplutā iti yathāsaṃkhyam | turīyāṇi madhye yathā prāṇabhṛto' timātrā madhyamāṃ svayamātṛṇṇāsaṃhitāmuttarastu vikarṇīm |

8.6 *iti suparṇasya |*

9

9.1 *yāvatī śoṣapākābhyāmiṣṭakā hrasate kṛtā |*
tāvatsamadhikaṃ kāryaṃ karaṇaṃ samamicchata ||

9.2 *sadā ca triṃśakaṃ bhāgamiṣṭakā hrasate kṛtā |*
tāvat samadhikaṃ kāryaṃ karaṇaṃ samamicchata ||

9.3 *ekaikaṃ śatamadhyardhaṃ tadūtaṃ*[38] *ṣaḍabhiraṅgulaiḥ |*
iṣṭakānāṃ parimāṇaṃ vaikṛtaṃ yadato' nyathā ||

9.4 *navāṅgulasahasrāṇi dve śate ṣoḍaśottare |*
aṅgulānāṃ parimāṇaṃ vyāyāmasya tu nirdiśet ||

9.5 *itareṣāṃ tu dhiṣṇyānāṃ sarveṣāmeva niścayaḥ |*
ekaikasya sahasraṃ syācchate ṣaṇṇavatiḥ parā ||

9.6 *ekādaśa sahasrāṇi aṅgulānāṃ śatāni ṣaṭ |*
śataṃ caiva sahasrāṇāṃ kṣetramagnervidhīyate ||

9.7 *prākṛtaṃ vaikṛtaṃ vāpi kṣetramardhāṣṭamāntare |*
pañcaviṃśaṃ śiraḥ kṛtvā tataḥ kṣetre samāvapet ||

9.8 *śatānyaṣṭau padonāni padānāmiha kīrtyante |*
sāṅgasya saśiraskasya kṣetraṃ kṣetravido viduḥ ||

9.9 *ātmā catuḥśataḥ kāryaḥ pakṣau triṃśacchatau smṛtau |*
daśa pucche śataṃ caiva śiraḥ syāt pañcaviṃśakam ||

9.10 *ekatriṃśas*[39]*trayastriṃśairvargaiḥ pañcāśakairapi |*
asaṃbhavatsu vargeṣu dvidhā bhidyeta iṣṭakā ||

9.11 *iṣṭakāhrāsavṛddhibhyāṃ dṛḍhāsu śatakeṣu*[40] *ca |*
matimāniṣṭakā bhāgairmantrātsaṃnāśayediti ||

9.12 *caturaśre pṛṣṭau vāpi pakṣapucchaśireṣṭakāḥ |*
dikto' padhānaṃ lokācca tathā lokastu lupyate ||

9.13 *adhyātmani ha vijñeyamupadhānaṃ vijānatā |*
rathantarabṛhallokairanyaṃ gāyatrayājñiyaiḥ ||

9.14 *yajuṣmatīnāṃ saṃkhyā tu sarvāsāṃ caiva niścitā |*
ekaikasyāṃ citau vāpi tāṃ me nigadataḥ śṛṇu ||

9.15a *ṣaḍaśītiḥ śataṃ tvādyā dvitīyā daśa saptatiḥ |*
trayodaśa tṛtīyā syācchataṃ cāhurmanīṣiṇaḥ ||

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[38] *tadūnaṃ*, G.

[39] *ekatriṃśattraya-*, L. N.

[40] *śatameṣu*, N.

9.15b *caturthī śatamekā syāttisraścaiveṣṭakāḥ smṛtāḥ |*
śatāni trīṇi pañcāśatṣaṭcaiva citiruttamā ||

9.16 *etāḥ sarvā yajuṣmatyo yābhiragniḥ prasūryate*[41] *|*
śeṣaṃ lokampṛṇābhistu citīnāmabhipūrayet ||

9.17 *etāḥ sarvā samāmnātāḥ yajuryāvatpravartate |*
tadetaddhi sahasraṃ syāccharkarābhiḥ sahocyate ||

9.18 *etā upahitāḥ samyagdhenavastu prajāyante |*
amuṣminyajamānāya kāmānduhyati sarvaśaḥ ||

9.19 *ṣaṣṭiṃ prajāpatiṃ veda yo hi saṃvatsaraḥ smṛtaḥ |*
gacchati brahmaṇo lokaṃ nākaṃ bradhnasya viṣṭapam ||

10

10.1a *vaiṣṇave yā prameyāya śulbavidbhiśca sarvaśaḥ |*
saṃkhyātṛbhyaḥ pravaktṛbhyo namo bharanto yo mase ||

10.1b *idaṃ bhūmya*[42] *bhajāmahe yā no mānakṛtāmiva |*
yajñiyaṃ mānamuttamaṃ vardhamānaṃ sve dame ||

10.2 *spaṣṭā bhūmirjuḥ śaṅkurmauñjaṃ śulbamabandhuram |*
citrādau nākṛtiḥ kāryā tithyṛkṣaṃ varuṇaśubham ||

10.3 *sarvāḥ prāgāyatā vedyaḥ karaṇaṃ yaskadehikam |*
ardhenārvasamaṃ sarvamucchedo jānu pañcakam ||

10.4 *madhyame 'rdhamṛtavyānāṃ nākasatpañcacūḍayoḥ |*
karaṇādyarthamuddiśya kṣetramardhāṣṭamāntaraḥ ||

10.5 *anaḥsiddhaṃ havirdhānaṃ pātrasiddhāḥ kharāḥ kharāḥ |*
cātvālaḥ paśubhiḥ siddho havirbhiḥ sāgnikāḥ kharāḥ ||

10.6 *maṇḍalārdhaṃ catuḥsrakti ratnināṃ vihitāḥ kharāḥ |*
aratnirghana eteṣāṃ bhūyastve bhūyasībidhau ||

10.7 *pūrvaścaturviṃśatibhāge lekhyaścaturvaṃśairālikhitastu paścimaḥ syāddakṣiṇe' ṣṭadviguṇena lekhyastriṃśadbhirāyamya haretturāyam |*

10.8 *udakprakramya cātvālaṃ śāmitraṃ prakrame tataḥ |*
bhūyastatpaśubhūyastve vṛddhiruttarato bhavet ||

10.9 *āyāmabāhuṃ nikṣipya*[43] *vistarastu tathā pṛthak |*
so 'dhyardhaṃ guṇayedrāśiṃ sa sarvaguṇito ghanaḥ ||

10.10 *āyāmamāyāmaguṇaṃ vistāraṃ vistareṇa tu |*
samasya vargamūlaṃ yattatkarṇaṃ tadvido viduḥ ||

10.11 *śravaṇābhijitorbahulātiṣyayorvā citrāsvātyorantare 'psvagninā vā |*

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[41] *prasuyate*, G.
[42] *bhūmyā*, N.
[43] *kṣipya*, N.

10.12 *naktaṃ prācībhāskaraśrāyamāhuḥ | śaṅkulipte maṇḍale prākparākceti |*

11

11.1 *janmanā*[44] *rogahīno vā yajamāno bhavedyadi |*
kathaṃ tatra pramāṇāni prayoktavyāni kartṛbhiḥ ||

11.2 *yadyurutantuḥ keśovās*[45]*tṛtaḥ sarṣapo yavaścaiva ṣaḍguṇitaḥ ṣaḍguṇito bhavati narasyāṅgulaṃ māne taddvādaśakaṃ prādeśamityāhuḥ |*

11.3 *taddvayaṃ smṛto'ratniḥ prakramo'ratnisamaḥ sa dviḥprādeśo bhaveccitiṣu |*

11.4 *adhyardhāṅgulahīnāścatvāraḥ prakramā bhavenniyatāḥ |*

11.5 *tatraikādaśa yūpāścatvāraścaturuttarāḥ sattresattre |*

11.6 *ekasyāṃ vedyāmagnidvayamiṣṭakāriktaṃ bhavati | pṛthagato vediḥ cetpṛthagagniḥ klṛptaḥ |*

11.7 *viṃśatyaṅgulaḥ śataṃ niyataḥ pañcāratnirnaro daśapado vā | hīnātiriktayuktyā dehedehe pramāṇaṃ tu |*

11.8 *ṣaḍaśītiryugamuktaṃ sāṣṭādaśa ucyate tvakṣastantrasamasamastaṃ dvyujaṃ rathamīṣāṃ vyavāsyanti |*

11.9 *maṇḍalamatha caturaśraṃ maṇḍalaṃ ca yaḥ kurjāttasyemaṃ karaṇavidhiṃ tadvidāmudāhṛtaṃ śṛṇuta |*

11.10 *maṇḍalaviṣkambhārdha*[46]*samastribhujādavalambakaścatuḥsraktiḥ prāgāyatāt*[47]*tribhāgātkarṇāt sa maṇḍalaṃ bhavati |*

11.11 *puruṣaḥ puruṣaṃ kuryāttasyākṣṇayā dvipuruṣaṃ bhaveccaturastasyāpyakṣṇayā*[48] *dvābhyāṃ vā syāścatuḥpuruṣam |*

11.12 *dvipuruṣaḥ karaṇī śroṇī bāhustu dviguṇo bhavettriṃkuṣṭhavattryavalambakastato yaścaturaśre dvāṣṭamāḥ puruṣāḥ |*

11.13 *viṣkambhaḥ pañcabhāgaśca viṣkambhastriguṇaśca yaḥ |*
sa maṇḍalaparikṣepo na vālamatiricyate ||

11.14 *daśadhā chidya viṣkambhaṃ tribhāgānuddharettataḥ |*
tena yaccaturaśraṃ syānmaṇḍale tadapaprathiḥ ||

11.15 *caturaśraṃ navadhā kuryāddhanuḥkoṭyastridhātridhā |*
utsedhātpañcamaṃ lumpetpurīṣeṇeha tāvatsamaṃ ||

11.16 *caturaratnir*[49]*vā naraḥ sikatākaraṇe tvardhaṃ bhujaḥ pradiśyate |*

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[44] *janma*, N.

[45] *keśovāstṛṭiḥ*, N.

[46] *-viṣkambha* G, N.

[47] *-yataṃtriṃ-*, L. N.

[48] *caturastasyāpyakṣṇayā dvābhyāṃ vā syāscatuḥ puruṣaṃ | dvipuruṣaḥ karaṇī śroṇī bāhustu dviguṇo bhavet* not in L, and N.

[49] *caturaṅgulaṃ*, N.

11.17 *karaṇāni tato'syāḥ kārayettricatuḥpañcatrirabhiparyasya*[50] *yacchubhaṃ cayaneṣu vidhiḥ purātanairṛṣibhiryo'bhihitaśca nityaśaḥ* |

11.18 *parilekhanamānasaṃcayairvyatyāsyaiḥ parimāṇasaṃpadā vedyaḥ sarvāḥ pramāṇairāyāmena*[51] *ca vistareṇa ca mimīyāt*[52] |

11.19 *caturaśrasaṃpadādvyāyāmasamāpanāḥ smṛtā pañcāṅgyātha vā purātanairyāḥ pūrvairṛṣibhiḥ pradarśitāḥ* |

11.20a *yaścaiṣa vidhirmaryākṛtastatraiṣā mithunātsamaṃ* |
pañcāṅgī tāvatī rajjuryayā sarvaṃ mimīmahe ||

11.20b *ṛte kaṅkālajaśyenāṃ steṣāṃ vakṣyāmi lakṣaṇam* ||

11.21 *iyaṃ mitā yā samayārdhalakṣaṇā tataścaturthe bhavennirāñchanaṃ tato'rdhaśiṣṭā vistārasamā cayasya* | *yattataścatuḥkuṣṭhamihānayā caret* |

11.22 *prācītath*[53]*āyāmasamā*[54] *nidadhyātpāśau nikhanyādatha madhyaṃ ca* |

11.23 *unmucya paścādatha madhyame tatprāgdakṣiṇāyamya nirāñchanena vistārato'rdhe nikhaneta śaṅkum* | *pratyaktathottaramadhyame ca* | *sa vāsuvedīṣu*[55] |

11.24 *atha mānametacchroṇyāṃ tu pāśoddharaṇaṃ kriyeta* |

11.25 *aṃsaśroṇyorlikhet dikṣu lekhāḥ* | *śaṅkū*[56] *nihanyātsamareṣu teṣu* | *tebhyaḥ samantātparilekhayet* |

11.26 *yadyaiṣṭikā nobhau likheta śiṣṭau* |

11.27 *pūrve tribhāge tvapare ca siddhopasthi*[57]*tāvutkaradakṣiṇāgnī* |

11.28 *athānyadasya parilekhanaṃ tu madhye bhaveddikṣu navāṅguleneti* |

12

12.1 *pramāṇārdhaṃ tu ṣaṣṭay*[58]*ūnaṃ viśeṣa iti sañjñitam* |
viśeṣaśca pramāṇaṃ ca pramāṇasyākṣṇayā[59] *bhavet* ||

12.2 *pramāṇārdhamanyatsyāt pāśaṣaṣṭhe sacaturviṃśe lakṣaṇaṃ karoti tannirāñchanamakṣṇayā tiryaṅmānī śeṣaḥ pāśādardhaśaye śroṇī dva*[60]......... |

12.3 ....*cāgnīdhramihopadiśyate* |

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[50] *ṭrayābhiparyasya*, N.
[51] *sarvāpramāṇinīrāyāmeṇa*, N.
[52] *miniyāt*, N.
[53] *pracīmathā-*, N, G.
[54] *-samām*, G.
[55] *sa vasuvedī-*, N.
[56] *śaṅku*, N.
[57] *siddhaubhasthitā*, N.
[58] *ṣaṣṭyūnaṃ*, G. N.
[59] *ajñayā*, G. N.
[60] Some portion has been dropped vide N. & G.

12.4 *agneryadakṣṇayāmānaṃ tasya caiva tadakṣṇayā |*
tadāśvamedhikaṃ vidyādekaviṃśadvidhau'thavā ||

12.5 *puruṣastiryagbhavedyadanudaśadhā yo mitaḥ |*
tasya karṇena yatkṣetraṃ vidyādekādaśaṃ tu tat ||

12.6 *ubhau bāhū naśakṣṇāṃ*[61] *tu narastiryaktadakṣṇayā |*
ekoccatānaikaśatādbāhuvṛddhayā[62] *vivardhayet ||*

13

13.1 *avalambakakuṣṭhe tu yo bhavetṣoḍaśāṅgule |*
sautrāmaṇyā bhavedeṣa prakramo mānakarmaṇi ||

13.2 *prakramasya tṛtīyena saumikī sārparājñikī |*
saṃtṛtīyaistribhiścānyaiḥ siddhamauttaravedikam ||

13.3 *caturdaśāṅgulo vā syātprakramastena saumikī |*
śatairdvādaśabhirvāpi minuyātpāśukāmiva ||

13.4 *sacaturthe vanaṃ ṣaḍbhirnavabhirvātha saptabhiḥ |*
navabhirvāparaṃ cakraṃ karaṇārdhe na lekhayet ||

13.5 *caturṣu nivapedeṣāṃ sāvitrādiṣu yo vidhiḥ |*
aruṇe jānudaghne nikhanyādadbhistu pūrayet ||

13.6 *caturaśramathāpi maṇḍalaṃ dvividhaṃ gārhapatyalakṣaṇaṃ vyāyāmamitaṃ caturbhujaṃ puruṣārdhena tu maṇḍalaṃ parilikhet |*
13.7 *vyāyāmatṛtīyamāyāntaṃ caturaśraṃ saptamabhāgavistṛtaṃ prāgācitamuttarācitaṃ vyatyāse tadathaikaviṃśakam |*
13.8 *puruṣasya tṛtīyamāyāntaṃ caturaśraṃ ṣaḍbhāgavistṛtam | prathikaśca tadāyato bhavenmadhye tena samāyato bhavenmadhye tena samāstike śeṣau | koṇau prathikamitau samau tadvistārakṛtau viśākhaḥ |*
13.9 *ṣaḍbhāgakṛtāyāmo bhaveddvyardhe tu trikoṇasaṃsthite*[63] *|*
13.10 *caturaśravipāṇakaḥ prathiko'rdhaṃ prathikaśca yo mitaḥ |*
13.11 *karaṇāni bhavanti maṇḍale catvāri pramitāni bhāgaśaḥ |*
13.12 *madhye'sya catasra iṣṭakāḥ tatpūrvāparayordvayordvayam | prathiko' rdha viṣāṇikadvayaṃ punareva punaraiti maṇḍalamardhaprathikadvaye samaṃ saṃpūrṇam | tadathaikaviṃśakam |*
13.13 *vyatyāsamudaṅmukhena*[64] *saha vyatyasyedvetyuttarottaram |*
13.14 *adhyardhaṃ padyaṃ ca padyārdhapadyapādavatpadyārdhotsedhamityāhurgāyatre karaṇāni ca |*

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[61] *naśakṣāṇāṃ*, N.
[62] *bāhuvṛddhyā*, G.
[63] *trikoṇasaṃsthitaṃ*, N.
[64] *udaṅmukhasya*, N.

13.15 *caturguṇāṃ dvipuruṣāṃ rajjuṃ kṛtvā samāhitām |*
saṃbhāgajñātṛtodāntāṃ pañcāṅgīṃ tadvido viduḥ |

13.16 *madhyamātpāśayostodo gāyatramānamucyate | sāratnāvardhapuruṣe | caturaśrastayā mitaḥ | pakṣapucchāntayorvṛddhyā gāyatreṇetareṣubhiḥ |*

13.17 *iṣṭakā śoṣapākābhyāṃ triṃśanmānāttu hīyate |*

13.18 *tataḥ kṣetraṃ tricaturbhāgaṃ niruhyādāpayecchivam |*

13.19 *aṃsa uttare'ṃse*[65] *ca prācyo'dhyardhāstu viṃśatirdaśa*[66] *pucche dvirdvādaśakau pakṣayorabhitaḥ pucche tu pañca deyāḥ pañca prācīḥ pañcadaśa dadyācchirasi | caturaśītī pakṣayoḥ*[67] *pañcāśataṃ triṃśatamātmani padyā*[68] *bhavanti śatamekonaṃ pucche'ṃsaśroṇyorviṃśatirviṃśatiḥ pucche pakṣayordaśadaśāhuḥ |*

13.20 *adhyardhā daśa śirasi prācyudīcyo bhavanti |*

13.21 *pūrvopahitā prathamā padayujaḥ sarvā | dvitīyāvāgyujo'śvinī |*

13.22 *vyatyāsaṃ cinuyādevaṃ jānunāsya vartmasu |*

13.23 *tripadā alpakṣetrā ekacitikāścatuḥ karaṇayuktāḥ dhiṣṇyā bhavanti sāgnicityamantrāḥ sātiriktāśca |*

13.24 *adhyardhāstu catasro dve madhye nakulaścaturbhāgaḥ |*

13.25 *aśmā navamo' gnīdhre |*

13.26 *hotrīyamataḥ saṃvakṣyāmo | aṃsaśroṇyoḥ padyāśrayā nakulakā bahistisṛṣu dikṣvantaścaturdaśa padakacaturthāḥ sa yaḥ*[69] *pratidiśamaṣṭau padyā dikṣu vidikṣu*[70] *|*

13.27 *brāhmaṇācchaṃsye daśa caikā syurmadhye dvau dvau caturthyau nakulaśca*[71] *|*

13.28 *abhitastisraḥ padyā dve madhye 'dhyardhe śiṣṭeṣvaṣṭau |*

13.29 *adhyardhāḥ ṣaṇmārjālīye'ṃsa mārjālīyaṃ syāddakṣiṇapārśvena śāmitraṃ cātvālasya ca paścād vabhṛthakalpe*[72] *'pyevaṃ padamekatastripadastisro 'tirikteṣviti |*

14

14.1 *saptatriṃśatsārdhāḥ pakṣaḥ savyaśca śirasi catvāraḥ ṣaḍviṃśakastathātmā*[73] *śyene*[74] *pañcadaśakaṃ puccham | saptadaśakaṃ pucchaṃ dvayaṃ*

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[65] *aṃsāduttaramaṃsam*, N.
[66] *viṃśadbhidaśa pucche*, N.
[67] *pakṣau*, N.
[68] *padyāntā*, N.
[69] *sapta*, N.
[70] *vidikṣu*, not in L., N.
[71] *nakukalakasca*, N.
[72] *-vabhṛthalpe*, L. N.
[73] *-aṃsā*, N.
[74] *śyete*, L. N. ASB.

śirasyātmapakṣayoḥ[75] *klṛptamalajasya / bhāgasaṃdhāntayajñaiḥ pramitān*[76] *naracaturthe /*

14.2 *aṣṭau bhāgāḥ puccham kaṅkacite bhavanti pādayoścaturaḥ śirasi tu sapta jñeyāḥ śyenavadātmā ca pakṣau ca /*

14.3 *śyenālajakaṅkānāmaṣṭau sārdhā*[77] *vistṛtaṃ pucchaṃ catvārotmā dvau ca śiraḥ sarveṣāṃ pañcakau pakṣau /*

14.4 *śyenālajakaṅkānāṃ dvitricatuḥ kuṣṭhamityucyate puccham / pañcākṣṇāḥ pakṣapātrāstvakṣṇābhiḥ pariśritāḥ /*

14.5 *pucche dvau bhāgāvānayetpucchamalajena trikuṣṭhavattrīnśyenapucchācchirasi kaṅke*[78] *pādau tu haret /*

14.6 *prācīrdvādaśa sārdhā viṃśatirudīcīrbhavenmitā bhāgā / daśa pañca kaṅkacitāvalaja udīcīstrayodaśa sārdhāśca*[79] */*

14.7 *tricaturbhāgamānī syādrajjurardhatrayodaśī /*
madhye ca lakṣaṇaṃ tasyāścaturbhāgairnirāñchanam //

14.8a *bhāgikāścatvārastodā ardhaṣaṣṭhe 'paraḥ smṛtaḥ /*
ardhāśca me 'ṣṭame caiva navame daśame 'paraḥ //

14.8b *ardhadvādaśo vānyaḥ /*

14.9 *tataḥ prācīḥ prasārya tu tasyā nikhānayecchaṅkum / pāśayormadhyame' ṣṭame / caturthe vāhatya pāśam / āsajya madhyame nirāñchanam /*

14.10 *nirāyamya vinudyonmucya madhyamāt / abhito daśama āyamya bhāgā dvikacatuṣkāḥ / ardhaṣaṣṭhe' pi cāhatya pūrvādevaṃ samācaret / tulyaṃ śaṅkuṃ turye /*

14.11 *tataḥ prācīḥ prasārya tu ardhaṣaṣṭhakayoḥ pāśau/śaṅkū*[80] *ardhāṣṭame' ṣṭame / pragṛhya paścimaśaṅkū*[80] */ dvikayorvotsṛjettataḥ /*

14.12 *caturthanavamau śaṅkū*[80] *pravṛhedantimāvubhau /*

14.13 *aṣṭame pāśamāsṛjya*[81] *aṣṭamenaiva nigrahaḥ*[82] */ bhāgebhāge tataḥ śaṅkū tayoḥ /*

14.14 *aṣṭame pāśamāsṛjya*[83] *ādiśaṅkau nigṛhya ca /*
daśame śaṅkumāhanyātpucchārdhe alajasya tu //

14.15 *syārdhāṣṭame śaṅkuḥ kaṅkasya darśane smṛtaḥ /*

14.16 *trike pāśaṃ samāsṛjya daśakena nigṛhya ca /*
etābhyāmeva todābhyāṃ śaṅkū deyau tathottarau //

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[75] *dvayaṃ*, N.
[76] *pratimā*, G.
[77] *sardhā*, G.
[78] *puccha śirasi śenānkaṅke*, N.
[79] *daśārdhaśca*, N.
[80] *śaṅku*, N.
[81] *-āsajya*, N. G.
[82] *vigraha*, N.
[83] *-āsajya*, N.

14.17 *ardhadvādaśame pāśastriko nigrahaṇo bhavet |*
ādipāśe dvike caiva śaṅkū deyau tathottarau ||

14.18 *uttare dvikamāsajya dakṣiṇaṃ samayorharet |*

14.19 *caturthe śaṅkumāhanyādviparītaṃ samācaret |*
caturthe tu tadarthena nirgṛhya ca......... ||

14.20 *iti śyenasya rajjurdvādaśalakṣaṇā |*

14.21 *catvāri karaṇānyeṣām tricaturthena kārayet |*
navabhāgā akṣṇārdhākṣṇāḥ pañcakoṇāḥ ca bhāgaśaḥ ||

14.22 *prācīne pañcakoṇe dve athārdhākṣṇādvayaṃ nyaset |*
aṃsāgrayorathaikaikā evaṃ pakṣavipakṣayoḥ ||

14.23 *navabhāgaiścitaṃ madhyamakṣṇābhiḥ pariṣiñcate |*
pakṣāgre pañca patrāṇyevaṃ cākṣṇā vidhīyate ||

14.24 *vyatyāsākṣṇādvayaṃ tunde pañcakoṇe pratyaksthite |*
ardhākṣṇe kaṇṭhasaṃdhyośca pūrayedamitaṃ śiraḥ ||

14.25 *dve pakṣasaṃdhyorardhākṣṇe pucchasaṃdhyo*[84]*stathāpare |*
daśa pañca ca pucchāgre pakṣāgra ekaviṃśatim[85] *||*

14.26 *aupamāne cayane caiṣāṃ vyatyāse karaṇeṣu ca |*
rajjvāścāvapanaṃ hrāso śyenasiddhiriti sthitiḥ ||

14.27 *avakrapakṣamalajaṃ ca pūrvapakṣe tathāyutam |*
madhyāt prasiddhaṃ pucchaṃ śyene dāmnā prasidhyata iti ||

14.28 *navamātprāgbhāge śaṅkū turīyasya karaṇam |*
alaje pakṣārdhamavakratāddhyevaṃ bhavet ||

15

15.1 *puruṣasya tṛtīyapañcamau bhāgau tatkaraṇaṃ punaściteḥ |*
tasyārdhamathāparaṃ bhavettricitikamagnicitiścet[86] *||*

15.2 *aṣṭāvaṣṭau rammitā citiraṣṭaikādaśikā ca madhyamā |*
vyatyāsavatīrupanya[87]*sedaṣṭau dvādaśa cottamā citiḥ ||*

15.3 *pañcadaśanaraṃ kṣetraṃ praugacittatastvardham |*
madhyāddaśake trikuṣṭhametattathā karaṇam ||

15.4 *bāhvorekaviṃśa ubhakaraṇe tathārdho 'nyaśca |*
aṃsaśroṇyośchedas[88]*tasyobhayato bhavet praugaḥ ||*

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[84] *pucchaṃsaṃdhyo*, N.
[85] *pakṣāgre viśavepṛthak*, N.
[86] *-triciti tairtamagnicitiścet*, N.
[87] *-rudanya-*, N.
[88] *-śchedatasya-*, N.

15.5 *cātvālebhyaścaturbhyastu samñhyo 'gniraniṣṭakaḥ |*
digbhyaḥ purīṣaiḥ samūhyo bhāgaśo yuktito vidhiḥ ||

15.6 *maṇḍalacaturaśro 'dya parivāryaḥ śmaśānacit |*
droṇacittsarumāneṣāṃ daśabhāgo bhavettsaruḥ ||

15.7 *maṇḍale caturaśraṃ tu kuryādgārhapatyavat |*
bāhvorviṃśatibhāgena vāruṇaṃ sārdhameva tu ||

15.8 *prasiddhaṃ daśadhā kuryādbahirantaśca yuktitaḥ |*
trikuṣṭhaśca viṣāṇaḥ syātsaṃdhau vyatyāsa eva saḥ ||

15.9 *caturaśrasya karaṇaṃ bāhvordvātriṃśadbhāgikam |*
caturaśramathādhyardhaṃ tābhyāṃ gāyatravadvidhiḥ ||

15.10 *sāhasrasya karaṇaṃ bāhvoḥ pañcadaśabhāgaṃ caturaśram |*
adhyardhāstu tataḥ syurdviśatāścitayaḥ smṛtāḥ ||

15.11 *pañca pañcāśatamadhyardhāstisraḥ pañcāśataṃ caturaśrāḥ |*
sahasrācchataṃ pakṣāḥ syuruṣā sahasratamī ||

15.12 *bāhvorekatriṃśo bhāgaḥ karaṇaṃ citistathottarayoḥ |*
caturasrāṇāṃ sāhasraṃ savanike vyavāsyanti ||

15.13 *ardhaikādaśapuruṣaṃ ghanaṃ bhavedbhavenmaṇḍalaṃ rathacakram | nābhirarā vivaradhā nemirarebhyo yadyatiriktam |*

15.14 *tadardhāḥ puruṣāyāmāḥ puruṣāṣṭabhāgavistṛtāḥ caturviṃśatistri-naranāyāḥ |*

15.15 *vivarakaraṇamataḥ sampravakṣyāmi | dvisaptamena nemyasra-karaṇaṃ bhavedarasyāṣṭabhāgena vaikṛtaścaturviṃśatibhāgena nābhyāman-taramantaro 'ṣṭamabhāgena praugavadbhavet |*

15.16 *dvīṣṭakāṃ cinuyānnābhiṃ*[89] *caturbhiścinuyādarān |*
tribhirnemiṃ yathābhāgaṃ vyatyāsaḥ kūpavat[90]*smṛtaḥ ||*

15.17 *viṣkambhasya caturthena nābhyāstu vivaraṃ likhet |*
tricatvāriṃśāṅgulāṃ nemiṃ sārdhacaturaṅgulām ||

15.18 *siddhamanyadyathā yuktiścayane yāśca sampadaḥ |*

15.19 *ya idamapi yathātathaṃ smṛtiṃ vidhiṃ yadādhītya mimīte rauravaṃ samavati khalu kṛtsnasaṃmato brajati ca śulbakṛtāṃ salokatām ||*

16

16.1a *rathacakrasya cityasya saṃkṣepoktasya viṣṇunā |*
atha dhāturnirviṣṭhasya triguṇānyaṃ bahirbahiḥ ||

16.1b *līyante maṇḍale yasya sapta sārdhā narā budhaiḥ |*

16.2 *mucyante vivareṣvanye kṣetrādabhyadhikāstrayaḥ |*

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[89] *nābhiścaturbhi*, N.

[90] *klupava-*, N.

16.3 *tasya cakravidhānaṃ tu nemirarebhyo vistaraḥ |*
maṇḍalānāṃ ca viṣkambhaḥ tribhāgaḥ karaṇāni ca ||

16.4a *narārdhenābhilikhennābhistataḥ prastāragocarā |*
arebhyo 'bhyadhikā nemistriṣaṣṭhenākṣarāgāram ||

16.4b *triṃśatena saviṃśena adhikaiścārdhapañcamaiḥ |*
mimāyāṅgulairvā madhyaṃ kuryādviṃśena parilekhanam |

16.5 *prathame prastare rathacakrasya sṛṇuteṣṭakāḥ |*
caturbhiradhikaṃ vettha catvāriṃśacchatatrayam[91] *||*

16.6 *dvitīye 'bhyadhikā yāntu caturviṃśatiriṣṭakāḥ |*
pañcakoṇāstrikoṇāśca nemyarebhyaḥ ca saṃdhiṣu ||

16.7 *iṣṭakānāṃ sahasreṇa śataiḥ saptabhireva ca |*
aṣṭaṣaṣṭyā ca cakrasya citayaḥ pañca pūritāḥ ||

16.8 *iti śulbasūtraṃ samāptam ||*

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[91] *catvāriṃśattarayaṃ*. N.

PART II

English Translation

BAUDHĀYANA-ŚULBASŪTRA

1

1.1 The various constructions of sacrificial fires are now given.

1.2 We shall explain the methods of measuring areas of their (different) figures (drawn) on the ground.

1.3 Now, the measure of an *aṅgula* is 14 *aṇus* (grain of *Panicum milliaceum*); according to others, (it is) 34 *tilas* (*sesamum indicum*) placed broad side on. One small *pada* is 10 *aṅgulas*; one *prādeśa* 12 *aṅgulas*; one *pṛthā* and one *uttara-yuga* 13 *aṅgulas* each; one (big) *pada* 15 *aṅgulas*. One *īṣā* measures 188 *aṅgulas*; one *akṣa* 104 *aṅgulas*; one *yuga* 86 *aṅgulas*; one *jānu* 32 *aṅgulas*; one *śamyā* and one *bāhu* 36 *aṅgulas* each. One *prakrama* equals 2 *padas* (30 *aṅgulas*); one *aratni* 2 *prādeśas* (24 *aṅgulas*). But there are also instances of *pada, yuga, prakrama, aratni* and *śamyā* having different measures when these (words) are used as units of measurement. 5 *aratnis* (120 *aṅgulas*) make one *puruṣa*; one *vyāma* also has the same measure (5 *aratnis*); and 4 *aratnis* (96 *aṅgulas*) make one *vyāyāma*.

1.4 Having desired (to construct) a square, one is to take a cord of length equal to the (side of the) given square, make ties at both ends and mark it at its middle. The (east-west) line (equal to the cord) is drawn and a pole is fixed at its middle. The two ties (of the cord) are fixed in it (pole) and a circle is drawn with the mark (in the middle of the cord). Two poles are fixed at both ends of the diameter (east-west line). With one tie fastened to the eastern (pole), a circle is drawn with the other. A similar (circle) about the western (pole). The second diameter is obtained from the points of intersection of these two (circles); two poles are fixed at two ends of the diameter (thus obtained). With two ties fastened to the eastern (pole) a circle is drawn with the mark. The same (is to be done) with respect to the southern, the western and the northern (pole). The end points of intersection of these (four circles) produce the (required) square.

1.5 Now another (method). Ties are made at both ends of a cord twice the measure and a mark is given at the middle. This (halving of the cord) is for the east-west line (that is, the side of the required square). In the other half (cord) at a point shorter by one-fourth, a mark is given; this is the *nyañcana* (mark). (Then) a mark is given at the middle (of the same half cord) for purposes of (fixing) the corners (of the square). With the two ties fastened to the two ends of the east-west line *(pṛṣṭhyā)*, the cord is to be stretched towards the south by the *nyañcana* (mark); the middle mark (of the half cord) determines the western and the eastern corners (of the square).

1.6 When (the construction of) a rectangle is desired, two poles are fixed on the ground at a distance equal to the desired length. (This makes the east-west

line). Two poles one on each side of each of the (two above mentioned) poles are fixed at equal distances (along the east-west line). A cord equal in length to the breadth (of the rectangle) is taken, its two ends are tied and a mark is given at the middle. With the two ties fastened to the two end poles (on either side of the pole) in the east, the cord is stretched to the south by the mark; at the mark (where it touches the ground) a sign is given. Both the ties are now fastened to the middle (pole at the east end of the *prāci*), the cord is stretched towards the south by the mark over the sign (previously obtained) and a pole is fixed at the mark. This is the south-east corner. In this way are explained the north-east and the two western corners (of the rectangle).

1.7 When the eastern side is desired to be of shorter measure, a mark is given at half (the *tiryaṅmānī*).

1.8 Now another (method). Ties are made at both ends of a cord of length equal to the measure increased by its half (so that the whole length of the cord is divided into three parts of half the measure each). In the third (extended) part on the western side a mark is given at a point shorter by one-sixth (of the third part); this is the *nyañcana*. Another mark is made at the desired point for fixing the corners. With the two ties fastened to the two ends of the east-west line *(pṛṣṭhyā)*, the cord is stretched towards the south by the *nyañcana*, and the western and eastern corners (of the square) are fixed by the desired mark.

1.9 The diagonal of a square produces double the area (of the square).

1.10 The breadth (of a rectangle) being the side of a given square *(pramāṇa)* and the length the side of a square twice as large *(dvikaraṇī)*, the diagonal equals the side of a square thrice as large *(tṛkaraṇī)*.

1.11 Thereby is explained the side of a square one-third the area of given square *(tṛtīyakaraṇī)*. It is the side of a square one-ninth the area of the square (explained in the preceding rule, that is, of the square on the *tṛkaraṇī*).

1.12 The areas (of the squares) produced separately by the length and the breadth of a rectangle together equal the area (of the square) produced by the diagonal.

1.13 This is observed in rectangles having sides 3 and 4, 12 and 5, 15 and 8, 7 and 24, 12 and 35, 15 and 36.

2

2.1 If it is desired to combine two squares of different measures, a (rectangular) part is cut off from the larger (square) with the side of the smaller; the diagonal of the cut-off (rectangular) part is the side of the combined square. (Alternatively: If it is desired to combine two squares of different measures, a rectangle is formed with the side of the smaller (square)

(as breadth) and that of the larger (as length); the diagonal of the rectangle (thus formed) is the side of the combined square).

2.2 If it is desired to remove a square from another, a (rectangular) part is cut off from the larger (square) with the side of the smaller one to be removed; the (longer) side of the cut-off (rectangular) part is placed across so as to touch the opposite side; by this contact (the side) is cut off. With the cut-off (part) the difference (of the two squares) is obtained.

2.3 A square intended to be transformed into a rectangle is cut off by its diagonal. One portion is divided into two (equal) parts which are placed on the two sides (of the other portion) so as to fit (them exactly).

2.4 Or else, if a square is to be transformed (into a rectangle), (a segment) of it is to be cut off by the side (of the rectangle); what is left out (of the square) is added to the other side. (Like *Āśl.* 3.1, the rule is defective and does not lead to proper geometrical operation).

2.5 If it is desired to transform a rectangle into a square, its breadth is taken as the side of a square (and this square on the breadth is cut off from the rectangle). The remainder (of the rectangle) is divided into two equal parts and placed on two sides (one part on each). The empty space (in the corner) is filled up with a (square) piece. The removal of it (of the square piece from the square thus formed to get the required square) has been stated.

2.6 If it is desired to reduce one side of a square (that is, to make an isosceles trapezium) the reduced side is to be taken as the breadth (of a rectangular portion to be cut off from the square); the remaining part (of the square) is divided by the diagonal and (one half), after being inverted, is placed on the other side.

2.7 If it is desired to transform a square into (an isosceles) triangle, the square whose area is to be so transformed is doubled and a pole fixed at the middle of its east side; two cords with their ties fastened to it (the pole) are stretched to south-western and north-western corners (of the square); portions lying outside the cords are cut off.

2.8 If it is desired to transform a square into a double (isosceles) triangle (that is, rhombus), a rectangle twice as large as the square to be so transformed is made; a pole is fixed at the middle of its east side; two cords with their ties fastened to it (the pole) are stretched to the middle points of the southern and northern side (of the rectangle); portions lying outside the cords are cut off; thereby the (isosceles) triangle on the other side is explained.

2.9 If it is desired to transform a square into a circle, (a cord of length) half the diagonal (of the square) is stretched from the centre to the east (a part of it lying outside the eastern side of the square); with one-third (of the part lying outside) added to the remainder (of the half diagonal), the (required) circle is drawn.

2.10 To transform a circle into a square, the diameter is divided into eight parts; one (such) part after being divided into twentynine parts is reduced by twentyeight of them and further by the sixth (of the part left) less the eighth (of the sixth part).

2.11 Alternatively, divide (the diameter) into fifteen parts and reduce it by two of them; this gives the approximate side of the square (desired).

2.12 The measure is to be increased by its third and this (third) again by its own fourth less the thirtyfourth part (of that fourth); this is (the value of) the diagonal of a square (whose side is the measure).

3

3.1 Now, the placement of the *āhavanīya* from the *gārhapatya* in the arrangement for the laying of sacrificial fires (will be discussed). According to tradition, the Brāhmaṇa has to place this fire (*āhavanīya*) (at a distance of) 8 *prakramas,* the prince 11 *prakramas* and the merchant 12 *prakramas* (from the *gārhapatya* towards east).

3.2 Three squares of side one-third the distance (between the *āhavanīya* and the *gārhapatya*) are made so as to be in contact with each other (along the east-west line); the *gārhapatya* (fire) lies at the north-west and the *dakṣiṇāgni* *(anvāhāryapacana)* at the south-east corner of the western square; the north-east corner of the eastern square marks the place of the *āhavanīya.*

3.3 Alternatively, the distance between the *gārhapatya* and the *āhavanīya* is divided into five or six (equal) parts, a sixth or a seventh part is added, the whole (of the cord measuring the original distance plus the added part) is divided into three (equal) parts, and a mark is given at the end of the second part from the eastern extremity. (With two ties) fastened to (poles at) the two ends of (the distance between) the *gārhapatya* and the *āhavanīya,* the cord is stretched to the south by the mark and a pole fixed at (the spot reached by) the mark. This is the place of the *dakṣiṇāgni.*

3.4 Or else, the measure (between the *āhavanīya* and the *gārhapatya*) is increased by its fifth, the whole of it is divided into five parts, and a mark is given at the end of the second part from the western extremity. With two ties fastened to (poles at) the two ends of the east-west line (representing the distance between the two fires), the cord is stretched to the south by the mark and a pole fixed at (the spot reached by) the mark. This is the place of the *dakṣiṇāgni.*

3.5 The *utkara* is explained by doing the opposite (that is, by reversing the cord and stretching it to the north).

3.6 To the west of the *āhavanīya,* as per tradition, is the altar for the new and full moon sacrifice *(dārśapaurṇamāsa)*, measuring 96 *aṅgulas (yajamānamātrī)* (in the east-west direction).

3.7 This (measure) less its third (64 *aṅgulas)* forms the western side (of the altar) and half the measure (48 *aṅgulas*) the eastern side; after making in this way a rectangle shorter on one side, poles are fixed at the (four) corners.

3.8 A tie is given at each end of a cord twice as long as the side (of the above altar) and a mark at the middle. With two ties fastened to (poles at the two ends of) the southern side, the cord is stretched to the south by the mark and a pole fixed at (the spot reached by) the mark. Fixing the two ties at this (pole), the southern side is circumscribed (with an arc of a circle from end to end) by the mark. Thereby the northern side is explained. The eastern side is circumscribed in the same way by a cord double its length, and likewise the western side.

3.9 The tradition has it that the altar for animal sacrifice *(paśubandha)* has 10 *padas* on its western side, 12 *padas* as its east-west line *(prācī)* and 8 *padas* on its eastern side; how it is to be measured out has been explained. According to some, the altar is measured with the measures of a chariot (that is, with *akṣa* (104 *aṅgulas*) for the western side, *īṣā* (188 *aṅgulas*) for the *prācī*, and *yuga* (86 *aṅgulas*) for the eastern side). According to others, the sides are 10 *padas* each.

3.10 According to tradition, the *uttara vedi* is four-cornered and measured (on each side) by a *śamyā* (36 *aṅgulas*); in the absence of any particular direction, it is a square.

3.11 According to tradition, the *paitṛkī vedi* (used for performing *pitṛ-rites*) is formed with the third part. The third part of the *mahāvedi* is turned into a square; the side which produces one-third of this square makes that (of the *paitṛkī vedi*). Therefore, it is one-ninth of the area (of the *mahāvedi*). According to others, its side measures 96 *aṅgulas (yajamānamātrī)* and it is four-cornered, the corners being pointed to the four cardinal directions.

3.12 For performing the *sautrāmaṇī* sacrifice, the altar is advised to have an area one-third of the *mahāvedi.* If a third part of the *mahāvedi* is turned into a square its side will be 18 *padas.* It can also have, if one so desires, a shape in which one side is shorter and the other larger.

4

4.1 The sacrificial chamber *(prāgvaṃśa)* is 16 *prakramas* long by 12 *prakramas* broad, or else 12 *prakramas* long by 10 *prakramas* broad.

4.2 (A length of) 12 *prakramas* is left in the middle between the sacrificial fires.

4.3 According to tradition, the *mahāvedi* measures 30 *padas* or *prakramas* on its western side, 36 (*padas* or *prakramas)* along the east-west line and 24 *(padas* or *prakramas)* on its eastern side; how it is to be measured out has been explained. The *mahāvedi* is 6 *prakramas* from the *āhavanīya* (fire towards east).

4.4 The *sadas* (shed) lies 1 *prakrama* from there (east of the western edge of the *mahāvedi*) and is 10 *prakramas* wide (in the east-west direction) and 27 *aratnis*, according to another opinion, 18 *aratnis* long in the south-north direction.

4.5 The *havirdhāna* (shed for the *soma*-vehicles) lies 4 *prakramas* (to the east) from there; it is a square of 10 or 12 *prakramas;* how it (such a square) is to be measured out has been explained.

4.6 The *uttara vedi* is measured out at a distance of half a *prakrama* to the west of the pole of the *yūpāvaṭa* (sacrificial post fixed in pit). According to *soma*-sacrifice, the *uttara vedi* measures 10 *padas;* how it is to be measured has been explained.

4.7 The *cātvāla* (pit in the ground) measures 36 *aṅgulas,* or it may have any undefined measure.

4.8 The *uparavas* (holes over which the *soma* is ground) are each 1 *prādeśa* long, the distance between two of them being 1 *prādeśa*. A square of side equalling 1 *aratni* is made, poles are fixed at the (four) corners, and a circle of radius equal to half *prādeśa* is drawn (with each pole at the corner as centre).

4.9 Situated at a distance of 2 *prakramas* from the eastern half of the *sadas* (shed), the *dhiṣṇya* (fires) are each 2 *prādeśas* in diameter and separated from each other by the same distance (of 2 *prādeśas*).

4.10 The side of the (covered) place for (kindling) the *āgnīdhra* (sacrificial fire) is 5 *aratnis*.

4.11 Thereby the *mārjālīya* (covered place for cleansing sacrificial vessels) is explained; its door is made on the northern side.

4.12 The pits for sacrificial posts are (placed) at intervals of 1 *akṣa* (104 *aṅgulas*) and there are eleven of them as per tradition. The twentyfourth part of the sum of 10 *akṣas,* 11 *padas* and 8 *aṅgulas* is the *prakrama*. With this the altar is to be measured.

4.13 For the *aśvamedha* (horse sacrifice), the twentyfourth part of the sum of 20 *akṣas,* 21 *padas* and 8 *aṅgulas* is the *prakrama*. With this the altar is to be measured.

4.14 For the making of 11 pits along the eastern side, a strip of breadth half a *pada* is cut off from the eastern half of the *mahāvedi* and placed east of it in the east-west direction. In this (operation) 8 *aṅgulas* are not taken into account, and there is no mutual connection.

4.15 The pits for the sacrificial posts are 1 *pada* (each) in diameter; the circumference of the base of the pits is 3 *padas*.

5

5.1 The area of the fire-altar made for the first time is $7\frac{1}{2}$ square *puruṣa;* that for the second time $8\frac{1}{2}$ (square *puruṣa*); that for the third time $9\frac{1}{2}$ (square

puruṣa). Thus by successively adding one-fold (1 square *puruṣa*), (one can go) upto 101-fold. Thus it begins with the 7-fold fire-altar ($7\frac{1}{2}$ square *puruṣa*) and ends with the 101-fold.

5.2 Thereafter, to continue further, the 101-fold (fire-altar) is to be repeated (that is, after reaching 101-fold, no further increase is to be made). Otherwise, the sacrificial rite is to be performed without a fire-altar.

5.3 The *aśvamedha* (sacrifice) is an exception. If the *aśvamedha* (requiring a fire-altar of $21\frac{1}{2}$ square *puruṣa*) is performed without (the required *agni*) being reached, one fold is added to get the next higher fold (that is, $22\frac{1}{2}$ sq. *puruṣa agni*); no other procedure is allowed.

5.4 If (the required fire-altar is) surpassed, the fire-altar following the one surpassed is to be constructed.

5.5 But how is one fold to be added ?

5.6 The excess (to be added) to the original form (of the fire-altar) should be divided into 15 parts and two parts be added to each fold (of 1 sq. *puruṣa*; after 14 parts are in this way added to 7 folds of 7 sq. *puruṣa*, the remaining part is added to $\frac{1}{2}$ sq. *puruṣa*). The (new) fire-altar is to be laid with such (increased) $7\frac{1}{2}$ folds.

5.7 The height (of the fire-altar), according to some teaching, should be increased by the twenty-fourth part of the fifth of a *jānu* (32 *aṅgulas*).

5.8 Some construct the fire-altar from one fold ($1\frac{1}{2}$ sq. *puruṣa*) upwards (upto $6\frac{1}{2}$ sq. *puruṣa*) without wings and tail.

5.9 This is not justified because it contradicts earlier and later precepts.

5.10 In this connection some *Brāhmaṇas* maintain that among the fire-altars the making of the falcon-shaped one is the first sacrificial ceremony.

5.11 Other *Brāhmaṇas* maintain that after having constructed a larger fire-altar a smaller one should not be laid.

5.12 Our *Brāhmaṇa* teaches as follows: he is winged for the unwinged cannot fly; the two wings are longer (than 1 *puruṣa* in each case) by 1 *aratni*, and this makes the birds strong in their wings; the two wings and the tail measure 1 *vyāma* (each).

5.13 A falcon without wings and tail does not exist; so the fire-altar which is not seven-fold has neither wings nor tail; moreover, the construction of one-fold fire-altar after the seven-fold has been laid is inadmissible; for all this the seven-fold is the fire-altar to be made for the first time.

5.14 The clefts are to be avoided; the meetings of edges (between bricks) in the upper and lower layer constitute these clefts, as per teachings. Such clefts, however, do not exist either in the peripheries or the two sides of a corner of the fire-altar.

5.15 One thousand bricks are to be used when (the fire-altar is) constructed for the first time.

5.16 This number is to be completed in the fifth layer.

5.17 Where two hundred bricks are desired (for each layer), *pañcacoḍā* and *nākasat* (bricks) are to be counted together as one (that is, one of each type together to be considered as one brick).

6

6.1 The fire-altar indeed possesses the characteristics of an animal. The southern bones of an animal are on its southern (right) side; likewise its northern bones lie on its northern (left) side and *vice versa*. That (part) which is below (on the western side) is the same as what is above (on the eastern side). In the same manner bricks of different forms are to be placed (in the fire-altar).

6.2 (Bricks marked with) lines turned to the right are placed on the southern side, those with lines turned to the left on the northern side, those with straight lines on the east and the west side, and those with three lines in the middle (of the fire-altar). The placing (of the bricks) in the middle (along the east-west line of the fire-altar) is to be understood in the same way as the backbone of the animal which does not lie more on one side than the other (but passes strictly along the middle of its body).

6.3 On this the *Brāhmaṇa* has it that Prajāpati indeed is Atharvan and Agni is Dadhyaṅ, son of Atharvan, and the bricks are his bones.

6.4 (In a fire-altar) where exterior limbs (such as head, wings, tail, feet etc.) are to be fitted (to the body, that is, the *ātman* of the altar), the middle of the side of the limb (concerned) is to be joined to the middle of that side of the body with which it (the limb) is to be in contact.

6.5 According to tradition, it (the fire-altar) is to be laid (with its head) towards the east.

6.6 The number of bricks is not to be completed with those which are not made of clay or which are not bricks.

6.7 As per teachings of this *Brāhmaṇa,* one fire-altar is laid with bricks, another with animals.

6.8 For the fire-altar has the characteristics of an animal: the *yoni* of an animal is of different forms; before laying the bricks, the sacrificial formulas from the *Yajus* text are recited.

6.9 Things occupying space are to be placed in holes (in the ground).

6.10 By (diagrams in the form of) circle, bull, woman, signs made on the bricks are to be understood.

6.11 If the number of sacrificial formulas (recited) falls short of the number of bricks, the difference is to be made good by (the sacrificial formulas called) *lokampṛṇas* because their number is unspecified.

6.12 Types of bricks previously used are to be placed here.

6.13 (There are) five *lokampṛṇas* (in every fire-altar).

6.14 If the number of sacrificial formulas exceeds (the number of bricks), anointed pebbles are to be placed in the interstices (between the bricks).

6.15 By the statements 'he places (the bricks) to the east', 'he places (the bricks) to the west' are meant the placement of types of bricks in a straight line (towards the specified direction).

6.16 By the statements 'he places (the bricks) to the east', 'he places (the bricks) to the west' are meant the directions faced by the constructor (of the fire-altar).

6.17 (Bricks) in the east are to be placed oppositely towards west and those in the west oppositely towards east; such is the rule of restriction.

6.18 This sort (of arrangement) is suitable for a square (fire-altar with four corners).

7

7.1 One should not use (for the laying of the fire-altar) a broken brick, a brick which is cleft, a blackened brick (due to over or under heating), a damaged brick and a brick with scratching marks. In the layer where a brick full of natural holes *(svayamātṛṇṇa)* is used it is not to be covered (by a brick).

7.2 The height of the brick is to be made a fifth of the *jānu* (that is, $6\frac{2}{5}$ *aṅgula*); that of the *nākasat* and the *pañcacoḍā* half of that measure (that is, $3\frac{1}{5}$ *aṅgula*).

7.3 What is lost by drying and burning is to be made good by loose earth because of the flexibility of its quantity.

7.4 According to tradition, the *gārhapatya* fire has the measure of 1 *vyāyāma*.

7.5 It (*gārhapatya* fire) is a square by one tradition and a circle by another.

7.6 The (*gārhapatya* fire in the form of) square is to be divided into 7 parts (lengthwise) and then into 3 parts transversely. In the second layer, bricks are to be placed towards north (that is, the division in the first layer as aforesaid is to be reversed).

7.7 To place square bricks (instead of rectangular ones as indicated above), (square) bricks of sides one-sixth, one-fourth and one-third of 1 *vyāyāma* are made. Of them, 9 bricks of the first type and 12 of the second are placed in the first layer; 5 of the third type and 16 of the first are placed in the second layer.

7.8 Within the (*gārhapatya* fire in the form of) circle a square of the maximum size possible is drawn and divided into 9 parts (squares). The segments of the circle (between the circumference and the square) are divided into 3 parts each. The second layer is placed in such a way that the corners (of the square within the circle) lie at the centres of the segments (of the first layer).

7.9 The *dhiṣṇya* fires are one-layered in the form of a square or a circle.

7.10 Of these (*dhiṣṇya* fires), the *āgnīdhrīya* is divided into 9 parts, and in one part a stone is to be placed (instead of a brick.)

7.11 The *dhiṣṇya* fire of the *hotṛ* priest is divided into 9 parts and the 3 parts on the eastern side are divided into 2 parts each.

7.12 The others (*dhiṣṇya* fires) are each divided into 9 parts and then two parts, one in the centre and the other in the east, are combined.

7.13 Now the *mārjālīya* fire is divided into 3 parts and then the eastern and the western parts (taken together) are divided into 5 parts.

7.14 The bricks are to be made by mixing with ashes from the caldron.

7.15 This applies to those whose consecration lasts a year and not to those undergoing it for a smaller number of nights.

7.16 Thus (the laying of) the fire-altar is completed with the sacrificial formulas, (recited by the priest).

7.17 After (a fire-altar made of) three thousand (bricks), a fire-altar to be piled with metres (of the sacred hymns) is to be laid. This is because of a difference in the wish. This (fire-altar) is falcon-shaped, as it is natural (for all such fire-altars).

8

8.1 Now he who desires heaven is to construct a fire-altar in the form of a falcon.

8.2 It is of two different forms; one has its body in the form of a square and the other in the form of a falcon.

8.3 This is the tradition of both the *Brāhmaṇas*.

8.4 Five (bricks) are placed in the southern corner and five in the northern. '(Let there be) the strength of the goat',—with these (words) he places (the bricks) in the southern corner; '(Let there be) the strength of the bull',—with these he places in the northern corner; '(Let there be) the strength of the tiger',—with these he places in the southern wing; '(Let there be) the strength of the lion',—with these he places in the northern wing; and '(Let there be) the strength of the man',—with these he places in the middle. (This is one *Brāhmaṇa*).

8.5 The other *Brāhmaṇa* is: The fire-altar is that which is constructed in the likeness of the birds, that is, after the shadow cast by them while flying.

8.6 'To distinguish between the divine and the human (purposes), the fire-altar is to be constructed with square bricks',—thus teaches the *Maitrāyaṇī Brāhmaṇa*.

8.7 For (constructing) this (fire-altar), (square) bricks (of sides) the fourth, the fifth, the sixth and the tenth part (of a *puruṣa*, that is 30, 24, 20 and 12 *aṅgulas* respectively) are made.

8.8 Now the (area of the) fire-altar is measured out.

8.9 Two holes are made on a bamboo rod at a distance equal to the height of a man with uplifted arms; a third hole is made at the middle. What (measurement) is done elsewhere with the cord is done here with the bamboo rod.

8.10 The body (of the fire-altar) is a square of 4 *puruṣa*: its (southern) wing is a square of 1 *puruṣa* made longer on the southern side by 1 *aratni* and its northern wing is explained in the same way; its tail is a square of 1 *puruṣa* lengthened on the western side by 1 *prādeśa*. Thus, with the addition of (two) *aratnis* and (one) *prādeśa*, the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣa*) is accomplished.

8.11 In the placement (of bricks) at a distance of one-third *puruṣa* (40 *aṅgulas*) to the north from the end of the (southern) wing, 4 bricks of side equal to one-fifth (of a *puruṣa*) and 2 quarter bricks (one-fourth of the area of a *pañcamī* brick, that is, 12 sq. *aṅgula*) (are placed). Thereafter 8 bricks of side equal to one-fourth (of a *puruṣa*) (are placed). The remaining space of the (southern) wing is covered with bricks of side equal to one-sixth (of a *puruṣa*). Thereby the northern wing is explained.

8.12 Bricks of side equal to one-fourth (of a *puruṣa*) are to be placed on the eastern and the western side of the tail, and quarter bricks on its southern and northern side. The remaining space of the fire-altar is to be covered with bricks of side equal to one-fifth (of a *puruṣa*).

8.13 This is one layer of 200 bricks.

8.14 In the other layer, at a distance of half a *vyāyāma* (48 *aṅgulas*) to the north from the (southern) end of the wing, 3 rows of 3 bricks each of side equal to one-sixth (of a *puruṣa*) alternating with 2 rows of 2 bricks each of side equal to 2 *padas* (30 *aṅgulas*) are placed. The same (is done) for the northern (wing).

8.15 In the south-western corner (of the body), 9 bricks of side equal to one-sixth (of a *puruṣa*) are arranged in the form of a square; the same (is done) for the north-western corner.

8.16 9 bricks of side equal to one-sixth (of a *puruṣa*) alternating with 2 bricks of side equal to 2 *padas* are to be placed from the south-eastern corner (of the body) to the north-eastern.

8.17 The rest of the fire-altar is to be covered with bricks of side equal to one-fifth (of a *puruṣa*).

8.18 This is (another) layer of 200 bricks. (With these two types) alternating with each other, as many layers as desired are to be constructed.

9

9.1 Now another type (of square *śyenacit*).

9.2 (For this are required bricks of side equal to) one-fifth (*pañcamī*) of a *puruṣa*; (those) with one side longer by half (*adhyardhā*) of one-fifth (of a *puruṣa*); (these equal to) a half of its size (*ardhyā* of the *pañcamī*); and (those equal to) a quarter of its size (*pādyā* of the *pañcamī*).

9.3 In the placement (of bricks), half bricks (half of *pañcamī*) turned towards north are placed on the eastern and the western side of the (southern) wing; the same (is done) for the northern (wing).

9.4 4 bricks longer by half and turned towards north (are placed) on each of the southern and northern side of the tail; 4 half bricks turned towards north (are placed) on the western side of the tail; and 2 quarter bricks on either side of them (that is, in two corners of the tail's west end). 1 half brick turned towards east (is to be placed) at each of the two places where the tail is joined with the hind part (of the body) (that is, at two corners of the eastern side of the tail).

9.5 The rest of the fire-altar is to be covered with *pañcamī* (bricks).

9.6 This is one layer of 200 bricks.

9.7 In the other layer, 4 quarter bricks (are placed) on each in the 4 corners of the body; 2 half bricks on two sides of them (in each corner); 5 half bricks on the eastern front (of the body).

9.8 At the end of each wing, 3 bricks longer by half (are placed) oriented towards north and 1 half brick (is placed) in each of the interstices between them (*adhyardhā* bricks).

9.9 The rest of the fire-altar is to be covered with *pañcamī* (bricks).

9.10 This is (another) layer of 200 bricks. (With these two layers) alternating with each other, as many layers as desired are to be constructed.

10

10.1 Now (is described the construction of a fire-altar in the form of a falcon) with curved wings and extended tail.

10.2 Bricks for this (fire-altar) are made with side equal to one-fourth *(caturthī)* of a *puruṣa;* (then those equal to) a half of its size *(ardhyā* of *caturthī)* and a quarter of its size *(pādyā* of *caturthī).* The cutting (of the *caturthī* brick to obtain its half and quarter) is always to be done diagonally in the absence of any advice to the contrary.

10.3 (Then one should make) quarter bricks (with the same area as that of a *caturthī-pādyā*) bounded by four sides (measuring) ½ *pada*, 1 *pada*, 1½ *pada* and √2 *pada*. Two of them touching each other along their long sides (1½ *pada*) are made into (another) half brick (called *haṃsamukhī*, swan beaked, with the same area as that of a *caturthī-ardhyā*).

10.4 The fire-altar is now measured out. The body is 2 *puruṣas* (240 *aṅgulas*) in length by 10 *padas* (150 *aṅgulas*) in breadth. From its south-eastern corner towards north a mark is given at a distance of 1½ *prakrama* (45 *aṅgulas*); the same (is done) towards west. By stretching a cord over these (two marks), the (south-eastern) corner is to be cut off. Thereby is explained the cutting off of other (three) corners. This makes the body *(ātman)*.

10.5 The head is of 5½ *padas* (82½ *aṅgulas*) in length by ½ *puruṣa* (60 *aṅgulas*) in breadth. The two eastern corners of it are cut off with 1 *prakrama* (30 *aṅgulas*).

10.6 The tail measures 6 *padas* (90 *aṅgulas*) in the east-west and 2 *puruṣas* (240 *aṅgulas*) in the south-north direction. The two eastern corners of it are cut off with 3 *prakramas* (90 *aṅgulas*) each.

10.7 The (southern) wing is of 12 *padas* (180 *aṅgulas*) in length (along north-south) and 10 *padas* (150 *aṅgulas*) in breadth (along east-west). A pole is fixed at a distance of 6 *padas* (90 *aṅgulas*) to the east from the middle (of its western side) and at each of the two south-western corners (of the rectangular wing). With a cord (stretching between these three poles, a triangular area) is to be enclosed. The (triangular) area enclosed by the cord is to be cut off and placed on the eastern side (of the wing) (with its vertex) pointing towards east. This is the bending (of the wing). Thereby the bending of the northern wing is explained.

10.8 At the end of each wing, 5 squares of side equal to 1 *prakrama* (30 *aṅgulas*) are laid (in a row) so as to be in contact with each other; all of them are intersected diagonally in the downward direction (by joining the north-east corner to the south-east); and a half portion is removed (from each square).

10.9 Thus, with the addition of (two) *aratnis* and (one) *prādeśa*, the seven-fold (fire-altar of 7½ sq. *puruṣa*) is accomplished.

10.10 In the placement (of bricks), 1 *caturthī* is to be placed in the head at its junction (with the body) and 1 *haṃsamukhī* (swan-beaked) to the east of it. 2 quarter bricks are placed on two sides (of the *haṃsamukhī*), 3 four-sided quarter bricks below them on each side (of the head), and quarter bricks in the remaining space (of the head).

10.11 Alternatively, 1 *haṃsamukhī* brick is to be placed at the (eastern) extremity of the head and 1 *caturthī* below it, to be flanked by 1 quarter brick on either side. 3 four-sided quarter bricks are placed to the west (of these two quarter

bricks) and on each side (of the head) and quarter bricks in the remaining space (of the head).

10.12 5 quarter bricks mutually joined with one another are to be placed to the west of the head (on the eastern end of the body) and the same to the east of the tail (on the western end of the body). Half bricks as well as quarter bricks are to be placed in the truncated parts.

10.13 The rest of the fire-altar is to be covered with *caturthī* bricks. The number (of 200 bricks) is to be completed with quarter bricks and half bricks.

10.14 This is one layer of 200 bricks.

10.15 In the other layer, 4 *haṃsamukhī* bricks are to be joined with 4 quarter bricks so as to form a rectangle; this is placed breadth-wise in the space of the *svayamātṛṇṇa*.

10.16 At the junction of the tail (with the body), 2 *haṃsamukhī* bricks, (with their vertices) turned towards west and their ½ *pāda* sides lying within the body, are to be placed and below them and on both sides 3 quarter bricks (with their vertices) turned towards east.

10.17 At the western end of the tail 15 quarter bricks mutually joined with one another are to be placed.

10.18 In the plumages of the wing 2 quarter bricks alternating with 1 half brick are to be placed (from the west) to the east.

10.19 In the truncated areas at the joints (between the body and the wing, the bendings of the wing etc.), half bricks and quarter bricks are to be placed.

10.20 The rest of the fire-altar is to be covered with *caturthī* bricks. The number (of 200 bricks) is to be completed with quarter bricks and half bricks.

11

11.1 Now another type (of falcon-shaped fire-altar with curved wings and extended tail).

11.2 (In this case) the seven-fold (fire-altar) with (two) *aratnis* and (one) *prādeśa* is accomplished with 187½ (square bricks) of side equal to one-fifth of a *puruṣa (pañcamī)*.

11.3 The body can accommodate 52 of such (*pañcamī* bricks), the head 3½, the tail 15, southern wing 58½ and the northern wing the same (number of bricks as the southern).

11.4 The corners (of the rectangular body) are cut off with ½ *vyāyāma* (48 *aṅgulas*); the tail is inclined; the bending of the two wings is done with 3 *aratnis* (72 *aṅgulas*) each; the six plumages (at each end of the wings) are to be made with the half of bricks longer on one side by half (that is, half of *adhyardhā-*

pañcamī); the form of the head remains unchanged (that is, the same as that of the falcon-shaped fire-altar described before).

11.5 The different types of bricks (required for this fire-altar) are as follows.

11.6 Bricks of side equal to one-fifth of a *puruṣa* (*pañcamī*, 24 *aṅg*, × 24 *aṅg*.); bricks of which one side is longer by half (*adhyardhā*) (36 *aṅg*. × 24 *aṅg*.); bricks of which one side is longer by a quarter (*sapādā*, 30 *aṅg*. × 24 *aṅg*.); bricks which are quarter in size of those with side equal to one-fifth (of a *puruṣa*) (*pañcamī-pādyā*); bricks which are half in size (of the above, e.g., *pañcamī-ardhyā*); likewise, of bricks with side longer by half (that is, half and two types of quarter bricks made out of *adhyardhās*); triangular bricks made by joining two eighth parts, one from each of them (the eighth part of a *pañcamī* to be joined with the eighth part of an *adhyardhā*, called *ubhayī*); and bricks of which one eighth the size of those with side equal to one-fifth (of a *puruṣa*). These are the ten (different types).

11.7 The *pañcamī* bricks and their halves are to be placed in the body and the same in the tail.

11.8 The *adhyardhā* bricks and their halves (are to be placed) in the two wings.

11.9 In the head (are to be placed) such bricks as are possible (as can be accommodated).

11.10 In the other layer, 1 *ubhayī* brick (formed by combining the eighth part of a *pañcamī* with the eighth part of an *adhyardhā*) is to be placed at the eastern end of the (line of) junction of each wing (with the body); 1 *ubhayī* brick each at the western end (of the same line of junction); and 2 *ubhayī* bricks are to be placed on each side of the head.

11.11 At the western end of the tail, *adhyardhā* bricks (with the longer side) turned towards east, and at the two sides (western corners), bricks of size one-fourth and one-eighth (of a *pañcamī*) (are to be placed).

11.12 *Adhyardhā* bricks and parts thereof (are to be placed) in the two wings.

11.13 The remaining space (of the fire-altar) is to be filled with bricks such that these fit, the required number (of 200 bricks in the layer) is attained and the properties (of the fire-altar) are satisfied.

12

12.1 The body and the tail of the kite-shaped fire-altar (*kaṅkacit*) are explained in the same manner (as those of the *śyenacit* just described).

12.2 5 (*pañcamī*) bricks are to be accommodated in the head whose shape has been explained.

12.3 57 (*pañcamī*) bricks are to be accommodated in the southern wing and the same in the northern.

12.4 The bending of the two wings is done with 1 *vyāyāma* plus 1 *prādeśa* (that is, with 108 *aṅgulas*). 6 plumages (at each end of the two wings) are to be formed with 6 *pañcamī* half bricks. (An area equivalent to) $1\frac{1}{2}$ *pañcamī* is left.

12.5 With this (area left out), two feet each measuring 1 *aratni* (24 *aṅgulas*) long by 1 *prādeśa* (12 *aṅgulas*) broad are made on the western end of the tail at a distance of 1 *aratni* from each other; at each side of the western end (of each foot) 2 bricks of size one-eighth (of the *pañcamī*) (are placed).

12.6 Thus, with the addition of (two) *aratnis* and (one) *prādeśa,* the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣa*) is accomplished.

12.7 The different types of bricks (required for this fire-altar) are as follows: bricks of side equal to one-fifth (of a *puruṣa*) and parts thereof (half, quarter and one-eighth of *pañcamī* bricks); quarter bricks (having the area of a quarter *pañcamī*) bounded by four sides (measuring) $\frac{1}{2}$ *prādeśa* (6 *aṅgulas*), $1\frac{1}{2}$ *prādeśa* (18 *aṅgulas*), 1 *prādeśa* (12 *aṅgulas*) and $\sqrt{2}$ *prādeśa* (12 $\sqrt{2}$ *aṅgulas*); *adhyardhā* bricks (having the area of $1\frac{1}{2}$ *pañcamī*) bounded by four sides (measuring) $\frac{1}{2}$ *vyāyāma* (48 *aṅgulas*), 1 *aratni* (24 *aṅgulas*), 1 *aratni* (24 *aṅgulas*) and $\sqrt{2}$ *aratni* (24 $\sqrt{2}$ *aṅgulas*). These make six (types).

12.8 Of them, four-sided quarter bricks together with the one-eighths are placed in two feet, and the remaining space is to be filled with bricks such that these fit, the required number (of 200 bricks in the layer) is attained and the properties (of the fire-altar) are satisfied.

13

13.1 The body, the head and the tail of the fire-altar in the form of an *alaja* bird are explained in the same manner (as those of the *kaṅkacit*) with the two feet withdrawn.

13.2 63 *(pañcami)* bricks are to be accommodated in the southern wing and the same in the northern.

13.3 The bending of the two wings is done with 1 *puruṣa* (120 *aṅgulas).*

13.4 From (a pole fixed at a distance of) 1 *aratni* (24 *aṅgulas*) towards east from the western bend, a cord is stretched along the (line of) intersection of the westernmost plumage, and (the part lying west of the cord) cut off.

13.5 In this way (an area equivalent to) $5\frac{1}{2}$ *pañcamī* (bricks) stands removed.

13.6 1 quarter brick is placed at each western bend (to fill up the triangular void caused by the aforesaid removal). Out of the brick types the four-sided quarter bricks and the one-eighths are to be taken away, and the remaining space (of the fire-altar) is to be filled with (remaining types of) bricks such that these fit, the required number (of 200 bricks in the layer) is attained and the properties (of the fire-altar) are satisfied.

14

14.1 A fire-altar in the form of an isosceles triangle *(prauga)* is to be constructed as follows.

14.2 An isosceles triangle equal in area to the (seven-fold) fire-altar with (two) *aratnis* and (one) *prādeśa* (that is, $7\frac{1}{2}$ sq. *puruṣa*) is laid. Bricks (called *bṛhatī*) of length equal to one-twelfth of its western side and breadth equal to half (of the length) are to be made; then bricks which are half and quarter (of the *bṛhatīs*).

14.3 Of them, two half bricks with their hypotenuses turned outwards are to be placed in the apex and half bricks on both sides.

14.4 The rest of the fire-altar is to be covered with *bṛhatī* and the number (of 200 bricks) is to be completed with half bricks.

14.5 In the other layer, 47 quarter bricks mutually joined with one another are to be placed on the western side (of the triangle).

14.6 1 *śūlapādyā* (short-based quarter brick) in the apex (is to be placed).

14.7 4 quarter bricks,—2 wide-based *(dīrghapādyā)* and 2 of the other type (e.g. short-based, *śūlapādyā*), are to be placed in the space of the *svayamātṛṇṇa*, and half bricks on the two sides.

14.8 The rest of the fire-altar is to be covered with *bṛhatī* bricks (with length) turned towards east, and the number (of 200 bricks) is to be completed with half bricks.

15

15.1 A fire-altar in the form of a rhombus (made of two isosceles triangles, *(ubhayata prauga)* is to be constructed as follows.

15.2 A rhombus equal in area to the (seven-fold) fire-altar with (two) *aratnis* and (one) *prādeśa* (that is, $7\frac{1}{2}$ sq. *puruṣa*) is laid. As in the case of fire-altar in the form of isosceles triangle, bricks and their variations are to be made with the ninth part of the breadth (of the rectangle used for the construction of the rhombus).

15.3 The placement (of bricks in the first layer) is the same as before (as that of the isosceles triangle).

15.4 In the second layer, 2 (short-based) quarter bricks are to be placed in the apices and 2 (wide-based) quarter bricks at the meeting places (of the two isosceles triangles).

15.5 4 quarter bricks, —2 wide-based *(dīrgha-pādyā)* and 2 of the other type *(śūlapādyā)* are to be placed in the space of the *svayamātṛṇṇa* and half bricks on the two sides.

15.6 The rest of the fire-altar is to be covered with *bṛhatī* bricks (with length) turned towards east, and the number (of 200 bricks) is to be completed with half bricks.

16

16.1 According to tradition, a fire-altar in the form of a chariot wheel is to be constructed.

16.2 The chariot wheels are indeed of two types, e.g. those with spokes and those (formed) by the joining of circular segments (to a central square piece). In the absence of any distinction between the two, both are taken into consideration and described.

16.3 Now the (area of the) fire-altar is measured out. A circle of area equal to that of the (seven-fold) fire-altar with (two) *aratnis* and (one) *prādeśa* is made, the largest possible square is inscribed in it, and bricks are made with the twelfth part of its side.

16.4 6 of these (bricks) are placed in each circular segment and the remaining space (of the segment) is divided into 8 parts.

16.5 The other layer is to be so oriented that the corners (of the square) lie in the centres of the segments (of the first layer).

16.6 Now the other type.

16.7 Square bricks of area equal to the fifteenth part of half a (square) *puruṣa* are made for purposes of measurement.

16.8 With 225 of them (of such bricks) is accomplished the seven-fold (fire-altar) with (two) *aratnis* and (one) *prādeśa*.

16.9 To these (225 bricks) another 64 (bricks of the same kind) are added and with them (289 bricks) a square is made (as follows). (At first) a square is made with a side containing 16 bricks (in which 256 bricks are used up), leaving a balance of 33 bricks. These (33 bricks) are placed on all sides (actually on two adjoining sides, so as to obtain a square of side containing 17 bricks).

16.10 16 (bricks) at the centre constitute the nave; 64 (bricks thereafter) constitute the spokes and 64 the empty spaces (between spokes); the remaining (145 bricks) form the felly.

16.11 (The square shaped) nave at its borders is transformed into a circle (by the method previously described). The outer and the inner (squares) enclosing the felly are transformed into (two) circles. After dividing the space between the felly and the nave into 32 equal parts, the alternate ones are removed. In this way, the added area (equivalent of 64 bricks) stands withdrawn.

16.12 After dividing the felly into 64 equal parts and drawing (radial) lines (through these divisions), a circle is drawn through the middle (of the felly), making the number (of parts in the felly) equal to 128.

16.13 The spokes are each divided into 4 parts; the nave is divided into 8 parts.

16.14 This is the first layer (of 200 parts or bricks).

16.15 In the other layer, a circle is to be drawn within the nave at a distance equal to one-fourth (of the radius) from its inner edge. The same (is to be done) within the felly (at a distance equal to one-fourth of the felly's breadth) from the inner circumference.

16.16 After dividing the inner edge of the felly (that is, the circle drawn within it) into 64 equal parts, (radial) lines are to be drawn (so as to divide the felly into 64 parts).

16.17 (The space in each of) the spokes is divided into 5 parts from circle (in the nave) to circle (in the felly).

16.18 The space in each interstice of the felly is divided into 2 parts, and there is 1 part in each interstice of the nave.

16.19 The remaining space of the nave is to be divided into 8 parts.

16.20 These are the 16 types (of bricks required) in (the construction of) the fire-altar in the form of a chariot wheel with spokes.

17

17.1 According to tradition, a fire-altar in the form of a trough is to be constructed.

17.2 The troughs are indeed of two types, e.g. the square-shaped and the circular. In the absence of any distinction between the two, both are taken into consideration and described.

17.3 Now the (area of the) fire-altar is measured out. The body is a square of side equal to $2\frac{2}{3}$ *puruṣas*.

17.4 Its handle lies at the western side (of the body) and is $\frac{1}{2}$ *puruṣa* and 10 *aṅgulas* (that is, 70 *aṅgulas*) long towards east and $\frac{2}{3}$ *puruṣa* (80 *aṅgulas*) broad towards north.

17.5 Thus, with the addition of (two) *aratnis* and (one) *prādeśa*, the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣas*) is accomplished.

17.6 The different types of bricks (required for this fire-altar) are as follows: bricks of side equal to 1/6 *puruṣa (ṣaṣṭhi)*; bricks of side longer on one side by half *(adhyardhā)*, half bricks (of the *ṣaṣṭhi*) transversely cut; and bricks of side equal to $\frac{1}{4}$ *puruṣa (caturthī)*.

17.7 Of these, 6 *ṣaṣṭhī* bricks are placed on each of the two parts of the western side (of the body) between the handle and the corner, the rest of the fire-altar is to be covered with *bṛhatī* (that is, *adhyardhā*) bricks, and the number (of 200 bricks) is to be completed with half bricks.

17.8 In the other layer, 1 *adhyardhā* is to be placed in the south-eastern corner and the same on the north-eastern.

17.9 *Ṣaṣṭhī* bricks are to be placed on the eastern front (between the 2 *adhyardhās*).

17.10 Bricks of side equal to $\frac{1}{4}$ *puruṣa (caturthī)* are to be placed on the southern and the northern side (of the body).

17.11 2 *caturthī* bricks are to be placed on each corner of the east side of the handle, 2 *adhyardhā* bricks turned towards north-south below them on each side, and 2 *ṣaṣṭhī* bricks below them in the middle along east.

17.12 The rest of the fire-altar is to be covered with *bṛhatī (adhyardhā)* bricks turned towards east and the number (of 200 bricks) is to be completed with half bricks.

18

18.1 Now the other type (of *droṇacit* in the form of a circle).

18.2 120 (square) bricks, each $\frac{1}{16}$ of a (square) *puruṣa* (*ṣoḍaśī*, side = $\frac{1}{4}$ *pu*. or 30 *aṅg*.) give the area of the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣa*) with (two) *aratnis* and (one) *prādeśa*.

18.3 One of them is taken away, and (the area equivalent to) the remaining (119 bricks) is transformed into a circle.

18.4 This (kind of transformation into circle) has been explained in the case of the fire-altar in the form of a chariot wheel of the first type.

18.5 The *ṣoḍaśī* (brick which is taken away) is placed in the middle of the east side (of the square equivalent to the area of 119 bricks) and with it the circle (of the same area as that of the square) is to be drawn.

18.6 The western part (of the *ṣoḍaśī* brick) cut off (by the circle) is placed on its eastern side.

18.7 The (four) circular segments (obtained by drawing the maximum possible square within the above circle and after placing 6 bricks of side equal to 1/12 of the side of the inscribed square on the base of the segment, as in the case of the chariot wheel) are each divided into 7 parts.

18.8 Bricks in the middle of the segments are each 1 *prakrama* (30 *aṅgulas*) wide.

18.9 The number (of 200 bricks) is to be completed by bricks half of the square bricks (made with 1/12 of the side of the inscribed square).

18.10 In the other layer, the brick in the middle of the (eastern) segment is placed in the lip (-shaped handle) and the space below it is divided into 2 equal parts.

18.11 This is the fire-altar in the form of a circular trough involving (the use of) nine types (of bricks).

18.12 The construction of the *samūhya* and the *paricāyya* (fire-altars) is explained in the same way as that of the fire-altar in the form of the chariot wheel as already discussed.

18.13 Pits are dug out in the (four) cardinal directions of (the space to be occupied by) the *samūhya*, and the earth is collected from them and placed on the *samūhya* (instead of the bricks).

18.14-18.15 The positioning of bricks in the *paricāyya* is different (from that of the chariot wheel); these are placed all around in (concentric) circles turning towards right.

19

19.1 According to tradition, a fire-altar in the form of a pyre *(śmaśānacit)* is to be constructed.

19.2 The entire (area of the) fire-altar is divided into 15 square-parts. How to do this has been stated.

19.3 A rectangle is made with its length equal to thrice (the side of) the square-part and breadth equal to half (the side of the square-part). Lines are drawn from the middle of its eastern side to the two western corners and the two outer parts are removed (so as to obtain an isosceles triangle). This (isosceles triangle) is divided into 10 parts.

19.4 The entire fire-altar is composed of 20 of them (of such isosceles triangles).

19.5 In the other layer, one of the (five) isosceles triangles (into which the entire fire-altar can be divided) is to be vertically bisected. Each half is divided into 6 parts. These two (half isosceles triangles each divided into 6 parts) are to be placed on either side (the southern and the northern side of the fire-altar).

19.6 Bricks of length equal to one-third (the side of the square part) and breadth equal to one-fourth (the side of the square part) are to be made, and then half of such bricks by transverse bisection.

19.7 After placing them (the half bricks) on the two ends (the eastern and the western), the rest of the fire-altar is to be covered with the *bṛhatī* bricks turned towards east, and the number (of 200 bricks) is to be completed with half bricks.

19.8 The height of the fire-altar is to be increased by one-fifth (of the *jānu,* that is, $6\frac{2}{5}$ *aṅgula*).

19.9 The whole of it (the height including the added 5th part) is divided into three parts and bricks are made with the fourth or the ninth or the fourteenth part of the two of these three parts (according as the fire-altar is intended to have 5, 10 or 15 layers).

19.10 With these bricks, 4 or 9 or 14 layers are made, the remaining layer (of thickness equal to one-third of the height) is diagonally cut in the downward direction and half of it removed.

19.11 Its division is exact. Larger and smaller bricks are taken according as these fit.

20

20.1 According to tradition, a fire-altar in the form of a tortoise *(kūrmacit)* is to be constructed by one desiring to win the world of the Supreme Spirit *(Brahmaloka)*.

20.2 The tortoises are indeed of two types, e.g. those with twisted limbs and those with rounded ones. In the absence of any distinction between the two, both are taken into consideration and described.

20.3 The fire-altar is measured out as follows. The body is a square of side equal to 10 *prakramas* (300 *aṅgulas*); its corners are cut off with 2 *prakramas* (60 *aṅgulas*) on each side.

20.4 4 squares each of side equal to 1 *prakrama* (30 *aṅgulas*) are made in (the middle of) the eastern front and 2 of them lying at either extreme are cut off by their diagonals. The same is done on the southern, western and northern front. This is the body.

20.5 The head is 5 *padas* (75 *aṅgulas*) long by $\frac{1}{2}$ *puruṣa* (60 *aṅgulas*) broad, of which the two eastern corners are to be cut off with 1 *prakrama* (30 *aṅgulas*) on each side.

20.6 The feet are to be raised where the corners (of the body) have been cut off. The foot (in the south-eastern corner) is $2\sqrt{2}$ *padas* ($30\sqrt{2}$ *aṅgulas*) broad by twice that measure (that is, $60\sqrt{2}$ *aṅgulas*) long and its eastern corner is cut off by $2\sqrt{2}$ *padas*. Thereby is explained the cutting off of the other (three) feet. Of the two feet at the western (corners of the body), their western corners are to be cut off.

20.7 Thus, with the addition of (two) *aratnis* and (one) *prādeśa*, the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣa*) is accomplished.

20.8 (Square) bricks of side equal to one-fourth of a *puruṣa*, and their halves and quarters (obtained by dividing the first type diagonally) are to be made for this (fire-altar).

20.9 (Then one should make) *adhyardhā* quarter (that is, one-fourth of *caturthīs* longer on one side by half) bricks bounded by four sides (measuring) 1 *prakrama*, 1 *pada*, 1 *pada* and $\sqrt{2}$ *pada*.

20.10 Two of them touching each other along their long sides (1 *prakrama*) are to be made into another (type of) brick *(haṃsamukhī)*.

20.11 (Then one should make) another (type of) square brick of side equal to half of $2\sqrt{2}$ *pada* (that is, $\sqrt{2}$ *pada* or $15\sqrt{2}$ *aṅgulas*).

20.12 In the placement (of bricks), a square brick (of side equal to $15\sqrt{2}$ *aṅgulas*) is to be placed at the top of the head, followed by two *haṃsamukhī* (bricks) below it.

20.13 5 square bricks and 2 quarter bricks *(pañcamī-pādyā)* are to be placed in each foot.

20.14 Half bricks are to be placed wherever a corner has been cut off.

20.15 The rest of the fire-altar is to be covered with *caturthī* bricks. The number (of 200 bricks) is to be completed with half bricks.

20.16 In the other layer, 1 *haṃsamukhī* at the top of the head and 1 quarter brick on either side of it are to be placed.

20.17 To the west of these on each side (of the head) 2 (four-sided) *adhyardhā* quarter bricks oppositely oriented are to be placed.

20.18 To the west of these on both sides are to be placed 2 quarter *(caturthī-pādyā)* bricks in alignment with the intersection.

20.19 2 *caturthī* (here called *dvipadās* or squares of side equal to 2 *padas* or 30 *aṅgulas*) and 3 half bricks are to be placed in each foot.

20.20 Half bricks and quarter bricks are to be placed wherever a corner has been cut off.

20.21 The rest of the fire-altar is to be covered with *caturthī* bricks. The number (of 200 bricks) is to be completed with half bricks.

21

21.1 Now the other type (of *kūrmacit* with rounded limbs).

21.2 120 (square) bricks of side equal to $\frac{1}{16}$ *puruṣa (ṣoḍaśī)* give the area of the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *puruṣa*) with (two) *aratnis* and (one) *prādeśa*).

21.3 Of them 5 *ṣoḍaśī* bricks are taken away, and (the area equivalent to) the remaining (115 bricks) is transformed into a circle. This (kind of transformation into a circle) has been explained in the case of the fire-altar in the form of a trough of the second type.

21.4 With 5 *ṣoḍaśī* bricks, (four) feet in (four) intermediate directions and the head in the east are to be raised. How to round off these bricks (for fitting with the circular body) has been explained.

21.5 The (four) circular segments (obtained by drawing the maximum possible square within the above circle and after placing 6 bricks of side equal to $\frac{1}{12}$

of the side of the inscribed square on the base of the segment as in the case of the trough) are each divided into 7 parts. Bricks in the middle of the segments are each 1 *prakrama* (30 *aṅgulas*) wide.

21.6 The resulting bricks in excess (of 200) are adjusted by square bricks longer by half on one side *(adhyardhā)*.

21.7 In the other layer, the feet are divided in the same manner as the head (in the first layer) and the head is divided like the feet (as in the first layer).

21.8 Alternating with each other as many layers as desired are to be constructed.

21.9 A little loose earth is to be placed on the edge of the tortoise (-shaped fire-altar) and a large quantity in the middle of it. In the (fire-altar in the form of) trough, the oposite is the case.

21.10 According to some (teachers), the fire-altars beginning with the one-fold should be (in the form of) isosceles triangles.

21.11 According to some other (teachers), (these should be in the form of) squares. Bricks are to be made with $\frac{1}{12}$ of the side of the square and half and quarter bricks thereof.

21.12 The increase (in the area) of the fire-altar for the *aśvamedha* (sacrifice) takes place by the *puruṣa* and not by (two) *aratnis* and (one) *prādeśa*.

21.13 This (*aśvamedha* fire-altar) is original and three times as large. Being three times as large, this fire-altar is twentyone-fold, and such is the tradition contained in both the *Brāhmaṇas*.

ĀPASTAMBA-ŚULBASŪTRA

1

1.1 We shall explain the methods of constructing (different) figures (on the ground for building sacrificial altars).

1.2 A cord of length equal to a given measure is increased by its half so that the whole length is divided into three parts of half the measure each. In the third part on the western side, a mark is given at a point shorter by one-sixth (of the third part). With the two ties fastened to the two ends of the east-west line *(pṛṣṭhyā)* the cord is stretched towards the south by the mark and a pole is fixed on it. The same is done towards the north. The same is repeated on the other side (eastern) after interchanging the ties. Thus are determined (the four corners of the right rectilinear figure). Thereby the sides are shortened or lengthened.

1.3 Alternatively, a cord of a given measure is increased by its length; the original length plus its fourth part will constitute the diagonal and the remaining (three-fourth part of the length) the breadth (of the rectangle). Thereby, the construction of a (right rectilinear) figure is explained.

1.4 The areas (of the squares) produced separately by the length and the breadth of a rectangle together equal the area (of the square) produced by the diagonal. By the understanding of these (methods) the construction of the figures as stated (is to be accomplished).

1.5 The diagonal of a square produces double the area (of the square). It is $\sqrt{2}$ *(dvikaraṇī)* of the side of the square (of which it is the diagonal).

1.6 The measure is to be increased by its third and this (third) again by its own fourth less the thirty-fourth part (of the fourth); this is (the value of) the diagonal of a square (whose side is the measure).

1.7 Here is another method (of construction of a square). Ties are made at both ends of a cord of length equal to the given measure. Marks are given at its middle and at mid points of its two halves. After stretching the cord along the east-west line poles are fixed at the ties and the marks. With the two ties fixed at the two poles at the two outer marks (mid-points of two halves), the cord is stretched towards the south by the middle mark and a sign is given (at the point reached). With the two ties fixed at the middle pole, the cord is (again) stretched by its middle mark towards the south over the sign (previously made) and a pole is fixed (at the point reached). With one tie (of the cord) fixed at this pole and the other tie at the eastern pole, the south-eastern corner is (now) obtained by (stretching the cord with) its middle mark. By removing the tie from the eastern pole and fixing it to the western pole, the south-western corner is likewise obtained by (stretching

the cord with) the middle mark. In the same manner, the north-western and the north-eastern corners (are obtained).

2

2.1 Now another method of construction (of a square). Poles are fixed at both ends and in the middle of the east-west line. A cord measuring half of the east-west line is taken and increased by its *viśeṣa* (the difference between its length and the diagonal of the square produced by it). After giving a mark at this point, the cord is (further) increased by half of the east-west line. Ties are made at both ends of the cord. Fixing the tie at the *saviśeṣa* end at the middle pole and the other tie at the eastern pole, the cord is stretched by the mark so as to obtain the south-eastern corner. By removing the tie from the eastern pole and fixing it to the western pole, the south-western corner is likewise obtained by (stretching the cord with) the mark. In the same way, the north-western and the north-eastern corners (are obtained).

2.2 The breadth (of a rectangle) being the side of a given square *(pramāṇa)* and the length the side of a square twice as large *(dvikaraṇī)*, the diagonal equals the side of a square thrice as large *(tṛkaraṇī)*.

2.3 Thereby is explained the side of a square one-third the area of a given square *(tṛtīyakaraṇī)*. It is the side of a square one-ninth the area of the square (explained in the preceding rule, that is, of the square on the *tṛkaraṇī*).

2.4 The combination of two equal squares has been described. The combination of two squares of unequal measures (sides) (now) follows. A (rectangular) part is cut off from the larger (square) with the side of the smaller; the diagonal of the cut-off (rectangular) part (produces the square which) combines both the squares. This has been stated.

2.5 If it is desired to remove a square from another, a (rectangular) part is cut off from the larger (square) with the side of the smaller one to be removed; the (longer) side of the cut-off (rectangular) part is placed across so as to touch the opposite side; by this contact (the side) is cut off. With the cut-off (part) the difference (of the two squares) is obtained.

2.6 That (the longer side of the cut-off rectangle in the above rule) which is placed across is the diagonal equal to the side of a square four times as large (as the given square). The area (of the squares) produced separately by the cut-off side and the other (the breadth of the rectangle) together equal the the area (of the square) produced by this diagonal. If the breadth produces one square *puruṣa*, the other side produces three square *puruṣas*. This has been stated.

2.7 If it is desired to transform a rectangle into a square, a (square) part is cut off (from the rectangle) by the breadth. The remainder (of the rectangle) is divided (into two equal parts) and placed on two sides. The empty space (in the corner) is filled up with a (square) piece. The removal of it (of the

square piece from the square thus formed to get the required square) has been stated.

3

3.1 If it is desired to transform a square into a rectangle, the side is made as long as desired; (after diagonal intersection), what remains as excess portion is to be placed where it fits. (Like *Bśl.* 2.4, the rule is defective and does not lead to proper geometrical operation).

3.2 If it is desired to transform a square into a circle, a cord is stretched from the centre (of the square) upto its corner (so as to measure out a length equal to half the diagonal). It is (then) stretched (from the centre) towards the (eastern) side. With one-third of the excess part (lying outside the eastern side) added (to the portion of the cord between the centre and the side), the (required) circle is drawn. This is the (approximate) circle, for (almost) as much is added as is cut off (from the corners of the square).

3.3 To transform a circle into a square, the diameter is divided into fifteen parts and two of them are removed, leaving thirteen parts. This gives the approximate (side of the) square (desired).

3.4 The (square) measure is to be done by means of the (linear) measure.

3.5 A square (of unit area) is to be understood in the absence of anything to the contrary.

3.6 (A cord of length) twice the measure produces four (square measures); thrice the measure nine (square measures).

3.7 The number of units of measure in a cord is to be squared (to get the area of the square in that measure). (Alternatively, as many units of measure there are in a cord so many rows of squares on each side will be in a square of side equal to the measuring cord.) This is the meaning.

3.8 A cord $1\frac{1}{2}$ *puruṣa* long makes $2\frac{1}{4}$ (square *puruṣas*); a cord of $2\frac{1}{2}$ *puruṣas* makes $6\frac{1}{4}$ (square *puruṣas*).

3.9 Now follows the method (of finding the area of a square) when the side is increased. With the side (of the given square) and the length by which the side is increased is drawn (a rectangular area) which is placed on either side (of the square). A square is formed with the length by which the side is increased and placed in the corner (to produce the enlarged square whose area is the sum of the given square, the two rectangles and the corner square piece).

3.10 With half the side of a square, a square one-fourth in area is produced, because four such squares to complete the area (of the original square) are produced with twice the half side. With one-third the side of a square is produced its ninth part.

4

4.1 The distance between the *gārhapatya* and the *āhavanīya* in the arrangement for the laying of sacrificial fires is known from the tradition. The Brāhmaṇa has to place it (the *āhavanīya*) (at a distance of) 8 *prakramas,* the prince 11 *prakramas* and the merchant 12 *prakramas* (from the *gārhapatya* towards east).

4.2 For general use and not for any particular class, this distance is indefinite, (about) 24 *prakramas* to be ascertained by eye estimation and should not deviate from it much.

4.3 According to tradition, the (place of the) *dakṣiṇāgni* is near the south-east corner of the third part of the distance of the *gārhapatya* (from the *āhavanīya*).

4.4 The distance between the *gārhapatya* and the *āhavanīya* is divided into five or six (equal) parts, a sixth or a seventh part is added, the whole (of the cord measuring the original distance plus the added part) is divided into three (equal) parts, and a mark is given at the end of the third part from the western end. (With two ties) fastened to (poles at) the two ends of (the distance between the *gārhapatya* and the *āhavanīya,* the cord is stretched to the south by the mark and a pole fixed (at the point reached by the mark). This is the place of the *dakṣiṇāgni*. This is according to *Śruti*.

4.5 The east-west line *(prācī)* has the measure of the sacrificer (96 *aṅgulas*) or of indefinite measure like that of clarified butter in relation to fire. Such is the case with the breadth. The two *aṃsas* (shoulders) of the fire-altar are to be raised in the east and the two *śroṇīs* (hips) in the west. It (the altar) is shorter on the eastern side, broader on the western side and curved in the middle. It is like a wooden doll. Such is the tradition of the *dārśikyā* fire-altar.

4.6 To the west of the *āhavanīya* is constructed the four-sided elongated figure of which the length has the measure of the sacrificer (96 *aṅgulas*). A cord equal to this measure is increased by itself and a mark given at the middle. With the two ties (of the cord) fastened to the (poles at the) south-western and south-eastern corners, it is stretched towards the south by the mark and a pole fixed (at the spot reached by the mark). Fixing both ends of the cord at this pole, an arc of a circle is drawn from the south-western to the south-eastern corner (with the middle mark of the cord). The same is done on the northern side (of the fire-altar). The western and the eastern sides are to be similarly circumscribed by means of a cord double the (respective) side.

5

5.1 According to tradition, the *saumikyā vedi* measures 30 *padas* or *prakramas* on its western side, 36 *(padas* or *prakramas)* along the east-west line and 24 *(padas* or *prakramas)* on its eastern side.

5.2 To a cord of 36 (*padas* or *prakramas*) another piece of 18 *(padas* or *prakramas)* is added and a mark is given at a distance of 12 and another mark at a distance of 15 from the western end (of the cord which is added). With

ties at both ends (of the cord) fastened to (poles fixed at) two ends of the east-west line, the cord is stretched towards the south by the mark at 15 and a pole fixed (at the point reached by the mark). The same is done towards the north. These (two points thus obtained) are the two western corners *(śronīs)* (of the altar). After interchanging the ties at two ends, the cord is stretched (towards the south) by the mark at 15 and a pole is fixed at the mark at 12. The same is done towards the north. These are the two eastern corners *(aṃsas)* (of the altar). This is the method of construction with one cord.

5.3 The diagonal of a rectangle of sides 3 and 4 is 5. With these (sides) increased by three times themselves, the two eastern corners (of the altar), and with these (sides) increased by four times themselves, the two western corners (are determined).

5.4 The diagonal of a rectangle of sides 12 and 5 is 13. With these (sides), the two eastern corners (of the altar) and with these (sides) increased by twice themselves, the two western corners (are determined).

5.5 The diagonal of a rectangle of sides 15 and 8 is 17. With these (sides), the two western corners (of the altar) (are determined). The diagonal of a rectangle of sides 12 and 35 is 37; with these (are fixed) the two eastern corners.

5.6 The knowledge of these (squared numbers) makes possible the construction of figures of the sacrificial altars.

5.7 The (area of the) *mahāvedi* is 1000 minus 28 (square) *padas*. From the south-east corner (a perpendicular) is dropped (on the western side) at a point 12 *padas* towards the south-western corner (from the east-west line). The (triangular) portion cut-off is placed invertedly on the other side. That makes a rectangle. By this addition (the area) is enumerated.

5.8 According to tradition, the *sautrāmaṇikī* sacrificial altar is one-third of the *saumikyā vedi*. (To find its dimensions), $\sqrt{\frac{1}{3}}$ of a *prakrama* is to be substituted for *prakrama* (in the values given for the *saumikyā*). Alternatively, the transverse sides will be $\sqrt{3}$ times 8 and 10 and the east-west line *(pṛṣṭhyā)* $\sqrt{3}$ times 12. The (area of the) *sautrāmaṇikī* sacrificial altar is 324 (square) *padas*.

6

6.1 According to tradition, the (area of the) altar for the *aśvamedha* sacrifice is double (the area of the *saumikī vedi*). (Here) $\sqrt{2}$ of a *prakrama* takes the place of a *prakrama*.

6.2 One *prakrama* equals 2 *padas* or 3 *padas;* on account of uncertainty in the meaning of the term *(prakrama)* one may take such value of *prakrama* as one may wish. The measure (of *pada*) may be that of the sacrificer or of the *adhvaryu*, because one directs the efforts of the other.

6.3 According to tradition, the altar for the conventional animal sacrifice *(nirudhapaśubandha vedi)* has the measures of a chariot. There it is said that the western side (of the altar) measures 1 *akṣa* (104 *aṅgulas*), the east-west line 1 *īṣā* (188 *aṅgulas*) and the eastern side 1 *yuga* (86 *aṅgulas*) or the distance between the two outside holes.

6.4 This (is to be constructed) by the methods of one cord already mentioned. Having stretched the cord by the mark at fifteen, the western corners are to be fixed by $\frac{1}{2}$ *akṣa* (52 *aṅgulas*) and the eastern corners by $\frac{1}{2}$ *yuga* (43 *aṅgulas*).

6.5 Now, these (units of chariot measure) are explained. 1 *īṣā* equals 188 *aṅgulas*, 1 *akṣa* 104 *aṅgulas* and 1 *yuga* 86 *aṅgulas*. These are according to the (Vedic) *Caraṇa* school and are known as chariot measures.

6.6 The western side is 4 *aratnis* or other measures, the east-west line 6 and the eastern side 3. This (is to be constructed) by the method of one cord already mentioned. Having stretched the cord by the mark at fifteen, the western and the eastern corners are to be fixed by 2 and $1\frac{1}{2}$ *(aratnis)* (respectively).

6.7 According to tradition, the *paitṛkī vedi* is a square, and has the measure of a sacrificer. This (is to be constructed) by the method of one cord already mentioned. Having stretched the cord by the mark at fifteen, the western and the eastern corners are fixed by half the measure.

6.8 According to the tradition of the *soma* sacrifice, the (side of the) *uttara vedi* measures 10 *padas*. This (is to be constructed) by the method of one cord already mentioned. Having stretched the cord by the mark at fifteen, the western and the eastern corners are to be fixed by half the measure.

6.9 These are measured by the *yuga*, *pada* or *śamyā* measures of the sacrificer.

6.10 One may take such value of *pada*, *yuga*, *aratni* and *śamyā* as one may wish when these (words) are used as units of measure, on account of uncertainty in the meaning of these terms.

6.11 In the measurement, the two sides should lie along the east according to tradition.

7

7.1 According to tradition, the *sadas* (shed) is 9 *aratnis* wide and 27 *aratnis* long in the south-north direction; according to some, its length is 18 *aratnis*. This (is to be constructed) by the method of one cord already mentioned. Having stretched the cord by the mark at 15, the western and the eastern corners are to be fixed by $4\frac{1}{2}$ *(aratnis)*.

7.2 According to tradition, the *uparavas* are each 1 *prādeśa* long, separated from one another by 1 *prādeśa*. A square of side equal to 1 *aratni* is made, poles are fixed at the (four) corners, and a circle of radius equal to half *prādeśa* is drawn (with each pole at the corner as centre) as per tradition.

7.3 According to tradition, the *gārhapatya* fire has the measure of 1 *vyāyāma*. It is a square by one tradition and a circle by another.

7.4 The brick (to be used for the *gārhapatya* fire) is to measure $\frac{1}{3}$ *vyāyāma* (32 *aṅgulas*) long by $\frac{1}{7}$ *vyāyāma* (13 *aṅgulas* 24 *tilas*) wide. There are 21 such bricks (required for each layer). In the first layer, the length (of the brick) is turned towards east, and in the second layer towards north.

7.5 For the circular (*gārhapatya* fire), a circular mound of earth is made and a pole fixed at the middle. (With this pole as centre) a circle is drawn with (a radius equal to) $\frac{1}{2}$ *vyāyāma* plus the extra (as per rule 3.2 for transforming a square into a circle). Within it (the circle) a square of the maximum size possible is drawn and divided into 9 parts (squares); each segment of the circle (between the circumference and the square) is to be divided into 3 parts.

7.6 In the placement (of bricks), the corners of square (in the first layer) point towards intermediate directions; in the other layer, these corners lie at the centres (of the segments of the first layer). (With these two layers) alternating with each other, as many layers as desired are to be constructed.

7.7 The *dhiṣṇya* fire, according to tradition, has the measure of the wooden vessel *(piśīlamātra)*; it is a square by one tradition and a circle by another.

7.8 Having made a circular mound of earth, the *āgnīdhrīya* fire is divided into 9 parts and a stone is to be placed. The other (*dhiṣṇya* fire) is divided into as many parts as prescribed and covered with bricks as they fit.

8

8.1 The tradition has it that he who constructs the fire-altar is certain to be (rich). It is constructed in the likeness of the birds, that is, after their shape, in pursuance of express direction (in the matter).

8.2 With the help of a bamboo rod of length (equal to a *puruṣa*) as mentioned, 4 (square) *puruṣas* are measured out for the body (of the fire-altar) and 1 (square) *puruṣa* is measured out for each of the southern wing, the northern wing and the tail. The southern wing is lengthened towards south by 1 *aratni* and likewise the northern wing towards north. The tail is lengthened towards west by 1 *prādeśa* or 1 *vitasti*.

8.3 The first *agni* is one-fold ($1\frac{1}{2}$ sq. *puruṣa*); the second two-fold ($2\frac{1}{2}$ sq. *puruṣa*); the third three-fold ($3\frac{1}{2}$ sq. *puruṣa*) and so on; in this way one continues upto hundred-and-one-fold *agni* ($101\frac{1}{2}$ sq. *puruṣa*).

8.4 But indeed the seven-fold (*agni*) only is to be constructed (first); (for) the seven-fold is the proper fire-altar. Thereafter, higher altars (are obtained) by increasing the area by one (sq. *puruṣa*) successively; this is the tradition.

8.5 The one-fold and the following (fire-altars up to the six-fold) do not have wings and tails, but the seven-fold does (have them) according to the injunctions of the *Śruti*.

8.6 In the case of eight-fold and higher order fire altars, their differences in area from the seven-fold should be divided in seven and half equal parts and each part added to each *puruṣa* (of the original seven-fold altar). This is because the deformation (of the fire-altar) is disallowed in the *Śruti*.

8.7 According to tradition, (the term) to be measured with a *puruṣa* means 'to be measured with a bamboo rod'.

9

9.1 Two holes are made (at the ends of) a bamboo rod at a distance equal to the height of the sacrificer with uplifted hands, and a third hole is made at the middle. Having placed the bamboo rod along the east-west line, poles are fixed in the holes from the western extremity; two poles from the western side are then taken off, and a circle is drawn (about the pole in the eastern extremity) with the other end (from the west) towards south-east. The pole is then removed from (the hole in) the eastern extremity and fixed at the western extremity, and a circle is drawn (about the pole in the western extremity) with the other end (from the east) towards south-west. The bamboo rod is taken off and one end of it is fixed to the middle (of the east-west line) with a pole; it is then placed towards the south so as to pass over the point of intersections of the two circles and a pole is fixed in the hole at the other extremity. The bamboo rod is fixed to this (last) pole by its middle hole and laid (east-west) touching the outer edges of the two circles; two poles are fixed through the two extreme holes. This is a square of (side equal to) one *puruṣa*.

9.2 Going about in this way, four squares each of one (sq.) *puruṣa* in the body *(ātman)* are measured out. One (sq) *puruṣa* (is then measured out) for each of the southern wing, the tail and the northern wing. As stated, the southern wing is to be increased towards south by one *aratni* and so on.

9.3 A bamboo rod equal to the diagonal of a square of side one *puruṣa* is placed across from (the western end of) the east-west line and another (rod of one *puruṣa*) is placed on the east side (from the eastern end). By them (that is, by their meeting point) the south-east corner is fixed. By reversing (the placement of the two rods), the south-west corner is fixed. Proceeding as before, the north-east corner is fixed.

9.4 As in the case of the *uttara vedi,* it is measured out with the help of a cord or a bamboo rod.

9.5 When the fire-altar having wings and tail is increased to higher folds or reduced, the *saptamakaraṇi* of the fold *(vidhā)* is to be substituted by the *puruṣa* and the area (of the fire-altar) drawn.

9.6 Of the bricks, the side (of the first type) should measure one-fifth of a *puruṣa;* the second type has one of its sides longer by half; the third type is one-fifth of a *puruṣa* long and one *prādeśa* broad; bricks with each side equal to one *prādeśa* form the fourth type; square bricks of side equal to one-fifteenth (of a *puruṣa*) constitute the fifth type.

9.7 The height of the brick is to be made a fifth of the *jānu* and that of the *nākasat* and *pañcacoḍā* half of that measure.

9.8 What is lost by burning (and drying) is to be made good by loose earth because of the flexibility of its quality.

10

10.1 In the placement (of bricks), 10 bricks longer by half (that is, 36 *aṅg* × 24 *aṅg*) and turned towards west are placed on the east side of the body *(ātman)*; 10 (of them) turned towards east on the west side (of the body); 5 (of them) at each end of the two wings; 5 (of them) at both junctions of the wings (with the body) such that half of the bricks (that is, the added half 12 *aṅg* of the *adhyardhā*) lie in the wings; and 5 bricks turned towards north and south on both sides of the tail.

10.2 After placing bricks of side equal to 1 *prādeśa* in the tail, all the (remaining) space of the fire-altar is to be covered with bricks of side equal to one-fifth (of a *puruṣa*).

10.3 The number (of 200 bricks) is to be completed with bricks of side equal to one-fifteenth (of a *puruṣa*).

10.4 In the other layer, 10 bricks longer by half and turned towards north are placed on the south side of the body and 10 (of them) turned towards south on the north side (of the body). (The placement of bricks) in the tail will be the same as in the wings for the first layer and that in the wings the same as in the tail (for the first layer). In the junction (between the tail and the body), (the placement of bricks should be) in the reverse order.

10.5 The whole (of the remaining) space of the fire-altar is to be covered with bricks of side equal to one-fifth (of a *puruṣa*).

10.6 The number (of 200 bricks) is to be completed with bricks of side equal to one-fifteenth (of a *puruṣa*). (With the two layers) alternating with each other as many layers as desired are to be constructed.

10.7 There are five layers; these are covered with five (layers of) loose earth, ending up with a layer of earth; (this is done) for various purposes (served by) loose earth.

10.8 The construction of the fire-altar for the first time should be with 1000 bricks upto (the height of) the knee; for the second time with 2000 bricks upto (the height of) the navel; for the third time with 3000 bricks upto (a height of) the mouth; and so on upto higher and higher heights. Those who

desire heaven should construct by increasing the height measure with innumerable bricks; this is the tradition.

10.9 In the case of (fire-altars employing) 2000 bricks, the piles will be two layered; in the case of 3000 bricks, three layered; in the case of 4000 and larger number of bricks, the number of bricks (for the layer) remains the same (as that for the 3000).

10.10 According to tradition, a smaller fire-altar should not be laid after a larger one has been constructed.

11

11.1 According to tradition, the fire-altar is to be constructed with four sided (bricks); in the absence of anything mentioned in particular, a square is to be understood.

11.2 (The bricks should be) of the measure of *pada, aratni, ūrvasthi* and *aṇūka;* this is the tradition.

11.3 *aṇūka* is one-fourth (of a *puruṣa*), *aratni* one-fifth (of a *puruṣa*), and so is *ūrvasthi* (one-sixth of a *puruṣa*).

11.4 The quarter bricks have the measure of a *pāda;* there one is free to choose owing to the wide range of the meaning of the word *(pāda)*.

11.5 In the placement (of bricks), 8 bricks of size quarter of the one-fourth (that is, 15 × 15 sq. *aṅg.*) are to be placed at each end of the two wings and 8 similar bricks at the (two) junctures (between the wing and the body) such that 6 *aṅgulas* (of the bricks) lie within the body. 8 bricks (of the same type) are placed on the western corners (of the body, 4 on each, lined) towards east and 8 bricks on the eastern corner towards west.

11.6 In the space (of the body) between the two junctures (with the wings), bricks of size one-fifth (of a *puruṣa*) and their quarters (are placed).

11.7 After placing bricks of size equal to 1 *prādeśa* in the tail, the whole of the (remaining space of the) fire-altar is to be covered with one-fourth bricks.

11.8 The number (of 200 bricks) is to be completed with quarter bricks.

11.9 In the other layer, one-fifth bricks are placed in the middle of the juncture of the tail (with the body). 14 bricks of size quarter of them (of one-fifth, that is, 12 × 12 sq. *aṅg.*) are placed around in the body as they fit.

11.10 The whole of the (remaining) fire-altar is to be covered with one-fifth bricks.

11.11 The number (of 200 bricks) is to be completed with quarter bricks. (With the two layers) alternating with each other as many layers as desired are to be constructed.

12

12.1 For one-fold etc. (upto the six-fold fire-altar), square bricks of side equal to one-twelfth and one-thirteenth of the side (of the fire-altar) are to be made

as also their quarters. (With the two layers) alternating with each other as many layers as desired are to be constructed.

12.2 From one-fold etc. (upto the six-fold), bricks are used in the first, second and third construction; in all cases and also for higher constructions, their number is according to the prescription of the *Śruti* (that is, 1000 bricks for all constructions).

12.3 The *kāmya* (fire-altars) are (endowed with) different merits and (are prescribed for the fulfilment of special desires) according to the science of merits *(guṇaśāstra)*.

12.4 Those who have many foes should construct a (fire-altar in the form of an isosceles) triangle; this is the tradition.

12.5 A square twice as large as the area of the (seven-fold) fire-altar with (two) *aratnis* and (one) *prādeśa* is laid; the mid-point of the eastern side (of the square) is joined to the two western corners (of the square, and the area lying outside these lines is cut off); this is the exact triangle (equal in area to the seven-fold fire-altars of $7\frac{1}{2}$ sq. *puruṣa*).

12.6 Bricks are to be made as in the case of one-fold etc. fire-altars (that is, of side equal to one-twelfth and one-thirteenth of the side of the altar); these should have the shape of an isosceles triangle.

12.7 According to tradition, those who wish to destroy existing and future enemies should construct a fire-altar in the form of a rhombus (made of two isosceles triangles, *ubhayata prauga*).

12.8 This (rhombus) looks like two inverted (fore parts) of a cart (joined together). As in the case (of the isosceles triangle), a rectangle (twice the area of $7\frac{1}{2}$ sq. *puruṣa*) is constructed and the mid-points of the eastern and western sides are joined to the mid-points of the southern and northern sides (of the rectangle, and the area lying outside these lines is cut off); this is the exact rhombus. (Bricks for this fire-altars are to be made in the same manner) as described in the case of the isosceles fire-altars.

12.9 According to tradition, a fire-altar in the form of a chariot wheel is to be constructed (when it is desired) to destroy enemies.

12.10 A circle of area equal to that of the (seven-fold) fire-altar with (two) *aratnis* and (one) *prādeśa* is made and the largest possible square is inscribed in it.

13

13.1 Bricks (for the construction of the chariot wheel fire-altar) are made with the twelfth part of the side (of the inscribed square).

13.2 6 of these (bricks) are placed in each circular segment and the remaining space (of the segment) is divided into 8 parts.

13.3 In the placement (of the first layer), the corners of the square should lie in the intermediate directions and in the other layer in the centres of the segments (of the first layer). (With these two layers) alternating with each other, as many layers as desired are to be constructed.

13.4 According to tradition, those who desired food should construct a fire-altar in the form of a trough.

13.5 The troughs are indeed of two types, e.g. the square-shaped and the circular.

13.6 One can construct the fire-altar of any one of these (two) types as one may wish.

13.7 Rather from considerations of quality a square *(droṇacit)* should be constructed.

13.8 According to tradition, the handle (of the trough) should lie on (its) western side.

13.9 The area of the handle is one-tenth of the total area (of the fire-altar). This being placed in the form of the tail (separate from the body), the area (of the square body) is found by the difference (of two squares) as already stated.

13.10 The (square) bricks are to be made with the twelfth part of the side (of the square body). Bricks longer by half *(adhyardhā)* and quarter bricks are also made.

13.11 In the placement (of the bricks in the first layer), the bricks longer by half are arranged on the eastern side of the body, turned towards west, at the (west) end of the handle and at the two western corners (of the body).

13.12 The remaining space of the fire-altar is covered with square bricks.

13.13 The number (of 200 bricks) is to be completed with quarter bricks.

13.14 In the other layer, the bricks longer by half are placed along the southern side of the body, turned towards north and along the northern side, turned towards south; the same is done along the southern and the northern side of the handle.

13.15 The remaining space of the fire-altar is covered with square bricks.

13.16 The number (of 200 bricks) is to be completed with quarter bricks. (With these two layers) alternating with each other, as many layers as desired are to be constructed.

14

14.1 Those who desire beasts should construct the *samūhya*, according to tradition.

14.2 Bricks are to be placed all around the *samūhya* (fire-altar).

14.3 The *cātvāla* pits (in the ground) are to be placed in every direction and levelled with clay with water *(purīṣa)* ; this is the tradition.

14.4 Those who desire villages should construct the *paricāyya* (fire-altar); this is the tradition.

14.5 The *paricāyya* is that (fire-altar) in which bricks are placed around the central *svayamātṛṇṇā* (brick).

14.6 According to tradition, the *upacāyya* is to be constructed by those who desire villages. It is prepared in a manner opposite to that of the *paricāyya* (that is, the construction proceeds from outside to the centre).

14.7 Those who desire prosperity in the abode of the Fathers should construct the fire-altar in the form of a pyre *(śmaśānacit)*; this is the tradition.

14.8 The pyres are indeed of two types, e.g. the square-shaped and the circular.

14.9 One can construct the fire-altar of any one of these (two) types as one may wish.

14.10 Rather from considerations of quality a square *(śmaśānacit)* should be constructed. In the square type, it should be like the trough without the handle, as already stated.

14.11 According to tradition, those who desire beasts should construct the fire-altar with the meters (in place of bricks).

14.12 According to one opinion, the entire (sacrificial ceremony) should be performed by means of meters, according to another, by the usual sacrificial fires.

15

15.1 Those who desire heaven should construct a fire-altar in the shape of a falcon; this is the tradition.

15.2 This (fire-altar) has curved wings and extended tail. The west side (of first half of the wing) is pushed upwards towards east and the east side (of the wing from the middle to the end) is pushed downwards towards west. In this way the wings of birds are said to be bent at their middle (part).

15.3 The (area of the) fire-altar is to be made seven-fold with (two) *aratnis* and (one) *prādeśa*. (Of the rectilinear *śyenacit*), the *prādeśa* (portion of the tail) and the fourth part of the body (*ātman*) together with 8 *caturbhāgīyās* (also from the body) (are to be taken out). Out of these (areas), three *(caturbhāgīyās)* form the head (of the falcon) and the remaining (area) is to be distributed between the two wings.

15.4 5 *aratnis* make 1 *puruṣa*, 4 *aratnis* 1 *vyāyāma*, 24 *aṅgulas* 1 *aratni* and half (of 24 *aṅgulas*, that is, 12 *aṅgulas*) 1 *prādeśa*. That is the definition.

15.5 The length of the wing is $9\frac{1}{2}$ *aratnis* and $\frac{3}{4}$ *aṅgulas*.

15.6 A tie is made at either end of a cord 2 *puruṣas* long and a mark given at the middle (of the cord). Having fastened the ties at the two western corners of the (southern) wing, the cord is stretched towards east by the mark; the same is done on the eastern side (of the wing). This makes the bending (of the wing). Thereby is explained (the bending of) the northern wing.

15.7 The body is 2 *puruṣas* long and $1\frac{1}{2}$ *puruṣas* broad.

15.8 At the place of the tail, a rectangle $\frac{1}{2}$ *puruṣa* broad and 1 *puruṣa* long towards west is constructed; a similar rectangle is constructed on its southern and northern side. These (latter, i.e. the southern and the northern) two (rectangles) are diagonally cut off such that the length (of the tail) at its juncture (with the body) is $\frac{1}{2}$ *puruṣa*.

15.9 At the place of the head, a square of side $\frac{1}{2}$ *puruṣa* is drawn; the mid-point of its eastern side is joined to the mid-points of the southern and the northern sides (and the parts lying outside these lines are cut off).

16

16.1 The western and the eastern corners (of the body) are cut off (by lines) in the direction of the junctures (of the body with the tail and the head). This is the (form) of the falcon.

16.2 Bricks are made with length equal to one-fifth *puruṣa* (24 *aṅg*) and breadth one-sixth *puruṣa* (20 *aṅg*.), the two sides being inclined (with each other) in such a way that these fit (with the shape of the wing). This is the first type.

16.3 Two of these (first type) bricks are joined along the east line (that is, the length). This is the second type.

16.4 That side of the first type, which is one-sixth *puruṣa* long is extended by one-eighth of a *puruṣa* (15 *aṅg*), and (the extended part) is bent so as to fit (with the shape of the fire-altar). This is the third type.

16.5 A (square) brick of side one-fourth of a *puruṣa* (30 *aṅg*) is lengthened by half; the (square) portion of side one-fourth *puruṣa* is diagonally cut off. This is the fourth type.

16.6 The fifth type of brick is half of the (square) brick of side one-fourth of a *puruṣa*.

16.7 By dividing it (the fifth type) by the diagonal, the sixth type (is obtained).

16.8 A rectangle of breadth one-tenth of a *puruṣa* (12 *aṅg*) and length one-fifth of a *puruṣa* (24 *aṅg*) in the direction from east to west is drawn. One each such rectangle is placed on its southern and its northern side. These two (latter, that is, the southern and the northern, rectangles) are cut off by diagonals passing through their south-west corners. This is the seventh type.

16.9 Like-wise another type is formed in which the northern rectangle is cut off by the diagonal passing through the north (-western) corner (the cutting off of the southern rectangle being as before). This is the eighth type.

16.10 The ninth type is obtained by dividing by both diagonals a (square) brick of side one-fourth of a *puruṣa*.

16.11 In the placement (of bricks in the first layer) 60 bricks of the first type turned towards north, are placed in each wing.

16.12 Along each side of the tail, 8 bricks of the sixth type are placed (in this way); three of them at the end (of the tail) and one above them and again three and one (above them).

16.13 At the juncture of the tail (with the body), 2 bricks of the fourth type partly covering both (the tail and the body) are placed. West of them (are placed) 2 bricks of the fifth class touching each other edge to edge.

17

17.1 The remaining space (of the tail) is covered by 10 bricks of the fourth type. 8 bricks of this type, turned towards east and west, are placed in the four corners (of the body).

17.2 The remaining space (of the body) is covered by 26 bricks of the fourth, 8 of the sixth and 4 of the fifth type.

17.3 In the head 2 bricks of the fourth type partly covering both (the head and the body) are placed and 2 of the same type, turned towards east, above them.

17.4 Thus is formed the (first) layer of 200 bricks.

17.5 In the other layer, 5 bricks of the second type are to be placed at each of the two bendings (of the two wings). At either juncture (of the wing with the body) (5) bricks of the third type are placed in such a way that the portion of each brick extended by one-eighth *puruṣa* lies within the body. The remaining space (of each wing) is covered by 45 bricks of the first type, turned towards east.

17.6 5 bricks of the seventh type are placed along each of the two sides of the tail. Next to such brick in the second row on one side and in the fourth row on the other side, one brick each of the seventh type is to be placed. The remaining space (of the tail) is to be covered by 13 bricks of the eighth type.

17.7 8 bricks of the fourth type, turned towards south and north, are placed in the western and the eastern corners (of the body). The remaining space (of the body) is covered by 20 bricks of the fourth type, 30 bricks of the sixth and 1 brick of the fifth type.

17.8 In the head are placed 2 bricks of the fourth type and east of them 4 bricks of the ninth type.

17.9 Thus is formed the (second) layer of 200 bricks.

17.10 (With these two layers) alternating with each other as many layers as desired are to be constructed.

18

18.1 Those who desire heaven should construct a fire-altar in the shape of a falcon; this is the tradition.

18.2 This (fire-altar) has curved wings and extended tail. The west side (of first half of the wing) is pushed upwards towards east and the east side (of the wing from the middle to the end) is pushed downwards towards west. In this way the wings of birds are said to be bent at their middle (part).

18.3 120 (square) bricks each $\frac{1}{16}$ of a (square) *puruṣa* (side, $\frac{1}{4}$ *pu.* or 30 *aṅg*) give the area of the seven-fold (fire-altar of $7\frac{1}{2}$ sq. *pu.*) with (two) *aratnis* and (one) *prādeśa*. Of them, 40 (can be accommodated) in the body *(ātman)*, 3 in the head, 15 in the tail, 31 in the southern wing and the same (number) in the northern (wing).

18.4 A rectangle, $1\frac{1}{2}$ *puruṣa* broad and 2 *puruṣas* long, is constructed. (An area equal to) 2 bricks of $\frac{1}{16}$th (square *puruṣa*) is discarded from each of the two western and the eastern corners, leaving (an area equivalent of) 40 *(ṣoḍaśī)* bricks. This is the body.

18.5 At the place of the head, a square of side $\frac{1}{2}$ *puruṣa* is drawn; the mid-point of its eastern side is joined to the mid-points of the southern and the northern sides (and the parts lying outside these lines are cut off). (An area equivalent of) 3 *(ṣoḍaśī)* bricks is left. This is the head.

18.6 A rectangle of breadth 1 *puruṣa* and length 2 *puruṣas*, further extended by an area of $\frac{1}{16}$ square *puruṣa* makes the southern wing. Likewise (is made) the northern wing.

18.7 At the end of (each) wing, 4 squares of side equal to $\frac{1}{4}$ of a *puruṣa* are made, diagonally divided, and their halves discarded. An area (equivalent of) 31 *(ṣoḍaśī)* bricks is left.

18.8 In the middle of the wing less the end portion (that is $\frac{1}{4}$ *puruṣa* or 30 *aṅg* with which the 4 squares were made), an east-west line is drawn. From (the western point of) the juncture of the wing (with the body) a cord of length 1 *puruṣa* is stretched and a point at the end of 1 *puruṣa* is given (where the end of the cord meets the east-west line). At a distance of 1 *puruṣa* from this point towards east another point is given. From these two points lines are to be drawn to the different end points (of the wing at the junction with the body and at the end less $\frac{1}{4}$ *puruṣa* where the 4 squares were made). This is the curving of the (southern) wing. Thus is explained (the curving of) the northern wing.

19

19.1 (An area bounded by a length of) 2 *puruṣas* on the western side, $\frac{1}{2}$ *puruṣa* on the eastern side, $\sqrt{18}$ (times $\frac{1}{4}$ *puruṣa* or 30 *aṅg*) on each of the two (southern and northern) sides and having a height of $\frac{3}{4}$ *puruṣa* can accommodate 15 *(ṣoḍaśī)* bricks. This is the tail.

19.2 The one-sixteenth *(ṣoḍaśī)* brick is to be bounded by four sides (whose measures are) : $\frac{1}{8}$ *puruṣa*, $\frac{3}{8}$ *puruṣa*, $\frac{1}{4}$ *puruṣa* and $\frac{\sqrt{2}}{4}$ *puruṣa.*

19.3 A half brick is bounded by three sides, two sides by $\frac{1}{4}$ *puruṣa* each and the other by $\frac{\sqrt{2}}{4}$ *puruṣa.*

19.4 A quarter brick is bounded by three sides,—one side by $\frac{1}{4}$ *puruṣa* and the other two by $\frac{\sqrt{2}}{8}$ *puruṣa* each.

19.5 A brick for use in the wing *(pakṣeṣṭakā)* is bounded by four sides,—two sides by $\frac{1}{4}$ *puruṣa* each and the other two by $\frac{1}{7}$ *puruṣa* each.

19.6 A brick for use in the middle of the wing *(pakṣamadhyīyā)* is bounded by four sides,—two sides by $\frac{1}{4}$ *puruṣa* each and the other two by $\frac{2}{7}$ *puruṣa* each.

19.7 A brick for use at the end of the wing *(pakṣāgrīyā)* is bounded by three sides, —one side by $\frac{1}{4}$ *puruṣa*, one side by $(\frac{1}{4}+\frac{1}{7})$ *puruṣa*, and the remaining side by $(\frac{\sqrt{2}}{4}+\frac{1}{7})$ *puruṣa.*

19.8 For making the brick for use in the wing *(pakṣeṣṭakā)* a rectangle of breadth $\frac{1}{7}$ *puruṣa* and length $\frac{1}{4}$ *puruṣa* is made and then lengthened by a diagonal (so that the other diagonal is shortened and the figure assumes the form of a parallelogram). The slabs are bent by the seventh of the distance between the root *(apyaya)* and the bending point of the wing *(pakṣanamanī).*

19.9 In the placement (of bricks), 4 quarter bricks are placed in the east of the head, 5 on the western side of the juncture of the head (with the body), 11 on the eastern side of the (eastern) juncture of the wings (with the body), 11 on the western side of the (western) juncture of the wings (with the body), 5 on the eastern side of the juncture of the tail (with the body) and 5 on the west of it, and 15 at the end of the tail.

20

20.1 4 bricks for use at the end of the wing *(pakṣāgrīyā)* are each placed at the end of the two wings and 4 at the juncture of the wing (with the body) each lying partly in both (the wing and the body).

20.2 Around these latter *(pakṣāgrīyā* bricks partly lying) in the body, 4 one-sixteenth bricks are placed on either side as these fit.

20.3 4 bricks for use in the middle of the wing *(pakṣamadhyīyā)* are each placed in the middle of the two wings. The two wings are (then) to be covered by

bricks for use in the wings *(pakṣeṣṭakā)*, (the longer sides of the bricks being) turned towards east.

20.4 The remaining space (of the fire-altar) is to be covered with one-sixteenth bricks; at the (inclined) edges (of the fire-altar) the diagonal sides (of these bricks) are to face outwards; elsewhere (their placement should be) as in the head.

20.5 In the other layer, 2 one-sixteenth bricks with their diagonal sides facing outwards are to be placed in the east of the head; west of them two of these with their diagonal sides facing inwards (are to be placed) partly covering the head and the body.

20.6 2 half bricks are to be placed as these fit, and these are to be enclosed by 2 half bricks with their diagonal sides facing outwards.

20.7 One-sixteenth bricks with their diagonal sides facing outwards are to be placed where the sides of the body meet (that is, at the western and eastern corners).

20.8 4 half bricks (are to be placed) at each end of the two wings. Two wings are (then) to be covered with bricks for use in the wings *(pakṣeṣṭakā)*, (their longer sides) turned towards north.

20.9 3 half bricks (are to be placed) at either side of the tail.

20.10 The remaining space (of the fire-altar) is to be covered with one-sixteenth bricks; at the (inclined) edges (of the fire-altar) the diagonal sides are to face outwards, elsewhere (their placement should be) as in the tail.

20.11 If square or triangular areas arise (due to the removal of *ṣoḍaśī* bricks for completing the number 200), these are to be covered by half or quarter bricks. *Aṇukās* in the place of *pañcadaśabhāgīyās* (are to be placed).

20.12 (With these two layers) alternating with each other as many layers as desired are to be constructed.

21

21.1 The kite-shaped fire-altar *(kaṅkacit)* and the fire-altar in the form of an *alaja* bird are explained after the falcon-shaped (fire-altar).

21.2 Like the falcon their two wings are larger than the tail and more curved (at the middle); the inclined tail is long (at the end and short where it joins with the body); neither the body nor the head is circular. This is according to the scriptures. Or, in pursuance of the sacred tradition, (the fire-altar may be) without the head.

21.3 And it is taught thus : 'One who wishes to live with the head on in this world should provide the *kaṅkacit* with the head'. Why is it said when one (always) has (the head)?

21.4 Naturally the two wings are curved and the tail is narrowed because such modifications are so heard. Where no (such) modification is heard, the body retains its natural form.

21.5 Thus it is constructed in the form of the falcon, and the shape has been explained after the sacred tradition.

21.6 According to tradition, the fire-altar for the *aśvamedha* (sacrifice) is three times as large (as the seven-fold with *aratni* and *prādeśa*).

21.7 All (sorts of) enlargements are possible in this case as nothing particular is mentioned.

21.8 The enlargement of the wings and the tail is stated to be brought about by the addition of rectangles.

21.9 It is (further) taught that, for the *aśvamedha* sacrifice, the fire-altar is of twenty-one.

KĀTYĀYANA-SULBASŪTRA

1

1.1 We shall explain (the method of measuring areas by) the combination of the cords.

1.2 Having put a pole on a level ground and described a circle round it by means of a cord (fastened to the pole), a pole is fixed on each of the two points where the end of the pole's shadow touches (the two halves of the circle). This (line joining the two points) is the east-west line *(prācī)*. Then after doubling (a given) cord, two loops (made at its two ends) are fixed at the two poles (of the *prācī*), and (the cord is stretched towards south by its middle point where) a pole is fixed; the same is repeated to the north. This (line joining the two poles) is the north-south line *(udīcī)*.

1.3 Two loops are fixed at the two ends of a cord. Marks are (to be given) at the *śroṇīs*, the *aṃsas*, the *nirañchana* and the *samāsabhaṅgas*. A pole is fixed at each end of the east-west line (of desired length); likewise (a pole is fixed at each of) the two *śroṇis* (west corners) and the two *aṃsas* (east corners). Having fixed the loops at the two poles (on the east-west line), the cord is to be stretched by the *nirañchana* mark towards the south-east corner. The same is done towards the north-east corner. After interchanging (the loops of the cord on the poles), the same is repeated. This is the method (of construction of squares and rectangles) in all cases.

1.4 Having doubled (the length of) a given measure, a mark is made at one-fourth of the added length; this is the *nirañchana* mark. (The length upto the *nirañchana* is) the diagonal *(akṣṇayā)* and the remainder the breadth *(tiryaṅmānī)*.

1.5 Or else, half the measure is added (to the measure) and a mark is made at the sixth part of the added length; this is the *nirañchana*. (The length up to the *nirañchana* is) the diagonal and the remainder the breadth.

1.6 For (constructing) a square *(samacaturaśra)*, a pole (is to be fixed) at half the measure. For (constructing) a rectangle *(dīrghacaturaśra)*, (the pole is to be fixed) at half (of the value) prescribed in the text. The same is for (the construction of) a triangle *(śakaṭa-mukha)*.

1.7 By these (methods) are explained the measurements of the sacrificial chamber *(prāgvaṃśa)*, the altars, as also the other chambers *(śālā)*. In these cases the north-south line (is used in the same manner) as in the east-west line. The same is for the *sadas* (tent).

1.8 By the word *aparimita* is to be meant a measure greater than the given measure.

1.9 For decrease *(nirhāsa)* or increase *(vṛddhi)* as also for addition, the method according to the direction of the text is to be followed.

1.10 We shall explain in what follows how to find the southern *agni* by (the method of) the third. (A cord of a length equal to) the distance between the *gārhapatya* and the *āhavanīya* is increased by one-sixth or one-seventh (of its length) and the length so increased is divided into three equal parts; the cord is stretched towards the south by the mark given at one-third from the other (western) end; at the point (thus obtained) the fire (is to be placed). The opposite point in the north is the place for the *utkara* (pit).

1.11 Alternately, with a cord of length equal to the distance (between the *āhavanīya* and the *gārhapatya* fire) reduced by one-third, a square is drawn in the eastern half; the fire *(dakṣiṇāgni)* (is placed) at the *śroṇī* (that is, at the south-western corner of the square). By reversing, the rubbish heap *(utkara)* (is placed) at the *aṃsa* (that is, at the north-east corner).

2

2.1 (The fire-altar is) measured by the units of a chariot expressed in *aṅgulas;* 188 *aṅgulas* make one *iṣā* (pole); 104 *aṅgulas* make one *akṣa* (axle of a cart); 86 *aṅgulas* make one *yuga* (yoke); and 32 *aṅgulas* make one *śamyā.*

2.2 For (the construction of) the *paitṛki (vedi),* a square of 2 *puruṣas* (in area) is constructed and a pole is fixed at the middle of each side; this is the solution.

2.3 (The terms) *karaṇī, tatkaraṇī, tiryaṅmānī, pārśvamānī* and *akṣṇayā* denote cords (measuring the sides of the areas).

2.4 The diagonal (of a right triangle) of which the breadth is *pada* and the length 3 *padas* is $\sqrt{10}$ *pādas.*

2.5 Similarly, the diagonal (of a right triangle) of which the breadth is 2 *padas* and the length 6 *padas* is $\sqrt{40}$ *padas.*

2.6 The *yuga* and the *śamyā* measures as seen (in the case of the *uttara vedi*) have already been stated.

2.7 The (area of the) square drawn on the diagonal of a rectangle is equal to the sum of (areas of) the squares drawn separately on its breadth and length; this is the property of plane figures (concerning rectangles).

2.8 The diagonal of a square produces a square twice as large (that is, the diagonal equals $\sqrt{2}$ times the side of the square).

2.9 The measure is to be increased by its third and this (third) again by its own fourth less the thirtyfourth part (of that fourth); this is the (the value of) diagonal of a square (whose side is the measure); this is approximate.

2.10 The diagonal (of a rectangle) of which the breadth is the side of a given square *(pramāṇa)* and the length the side of a square twice as large *(dvikaraṇī)* equals the side of a square thrice as large *(tṛkaraṇī)*.

2.11 Thereby is explained the side of a square one-third the area of a given square *(tṛtīyakaraṇī)*. It is the side of a square one-ninth the area of the square thrice as large *(tṛkaraṇī)*. (Alternatively,) the side of three-ninth the square of the original *(pramāṇa)* equals the side of a square one-third the area of a given square *(tṛtīyakaraṇī)*.

2.12 The side of a square one-third the area of a given square *(tṛtīyakaraṇī)* in *prakrama* is used in (the construction of) the *sautrāmaṇi* (sacrificial altar).

2.13 (By the preceding rules) the combination of squares of equal size is explained. To find a combination of two squares of different measures, a (rectangular) part is cut off from the larger (square) with the side of the smaller; the diagonal of the cut-off (rectangular) part is the side of the combined square.

3

3.1 If it is desired to remove a square from another, a (rectangular) part is cut off from the larger (square) with the side of the smaller one (to be removed); two poles are fixed on (two ends of) the cut and the line (thus obtained by joining the poles) is placed across so as to touch the opposite side; by this contact (the side) is cut off. With the cut-off (part) the difference (of two squares) is obtained.

3.2 (If it is desired) to transform a rectangle into a square (its breadth is taken as the side of a square and this square on the breadth is cut off from the rectangle), the remainder of the rectangle is divided into two (equal parts) and placed in its east and south side; (the empty space in the corner) is filled up by a (small extra) square piece. The removal of it (of the square piece from the square thus formed to get the required square) has been stated.

3.3 If (the rectangle be) very long, it should be cut again and again (into squares) making equal (the length to its) breadth; these squares are combined into one square; (to this is) added the (remaining) portion (of the rectangle) after transforming it suitably. This is the method of addition *(ekaḥ samāsaḥ)*.

3.4 A square intended to be transformed into a rectangle is cut off by its diagonal (by drawing a line from its north-west corner to south-east corner); one portion (again is subdivided) into two equal parts and are added, one to its east and the other to the north; for a trapezium the side is cut off and added as it fits.

3.5 By unit measure the square unit is to be understood. On specific direction, it may be otherwise.

3.6 Square on a side of 2 units is 4; on 3 units it is 9 and on 4 units it is 16.

3.7 The number of units (in the side of a square) measured by a cord, when multiplied by the same, will give the total number of squares.

3.8 Half of the unit will produce its one-fourth, one-third its one-ninth, one-fourth its one-sixteenth.

3.9 This is (the method of) deduction *(nirhāsa)* which has been explained before. This is according to (the injunction) of the *śāstra.*

3.10 Enlargement *(vivṛddhi)* and deduction *(hrāsa)* are made, depending on the unit of length in a cord *(rajjupramāṇa).*

3.11 If it is desired to transform a square into a circle (a cord of length) half the diagonal (of the square) is stretched from the centre to the east (a part of it lying outside the eastern side of the square); with one-third (of the part lying outside) added to the remainder (of the half diagonal), the (required) circle is drawn. This gives the solution.

3.12 If it is desired to transform a circle into a square, its diameter is divided into fifteen parts and two of them are removed. The remaining (thirteen parts) will be the side (of the square).

4

4.1 The altar in the shape of a trough, chariot wheel, falcon, triangle, rhombus and a kind of pot in the shape of a wheel are the (*citis* of the corresponding) fire-altars.

4.2 For construction of trough (*droṇacit*) a square equal to seven-fold fire-altar together with its wings and tail (i.e., $7\frac{1}{2}$ sq. *puruṣa*) is drawn and the tenth part of the area (after being transformed into a square) is joined to the original square like a stalk. This is according to some (teacher). The original square (having an area of $7\frac{1}{2}$ sq. *puruṣa*) is to be divided horizontally and vertically by drawing parallel lines from its tenth part; the (ten small squares) are then combined into a square (by the *ekasamāsa* method) and separated out. The remaining (squares are changed to a similar shape, i.e., a square). (Next) the previous part is to be joined to the latter (towards west like a stalk). The same (process) is adopted in the case of a circular *(droṇacit).*

4.3 In (the case of) an isosceles triangle *(prauga)* a square whose area is double the area of (the seven-fold) fire-altar with its wings and tail (i.e. $2\times7\frac{1}{2}=15$ sq. *puruṣa*) (is constructed) and a pole is put in the middle of the eastern side. This pole is then joined (by means of a cord) with poles at south-west and north-west corners. This gives (the construction for) the fire-altar.

4.4 In the case of rhombus *(ubhayata prauga)* a rectangle which has an area twice as much as in the seven-fold fire-altar together with its wings and tail, is constructed and poles (are fixed) at the middle point of each of its sides. This will give the solution.

4.5 (Having desired) to transform an isosceles triangle *(prauga)* into a square, the former is divided by the *prācī* line, one (of its parts) is placed on the opposite side after inverting it, and (the rectangle so formed) is transformed into a square by the (known) method of addition. This is the solution.

4.6 (Wishing to transform a rhombus into a square), it (the former) is bisected by its transverse middle line and recombined as before.

4.7 By this (method) the transformation of a triangle (into a square) is explained. This also explains the method of (constructing) a pentagon. A pentagon of equal angles is to be cut off into isosceles triangle and that having two types of angles into square.

5

5.1 How one hundred-and-one-fold fire-altar (from the original seven-fold fire-altar) is obtained gradually (by adding one square *puruṣa*) will be explained.

5.2 Two times, three times of the original fire-altar (which is $7\frac{1}{2}$ sq. *puruṣa*) is to be constructed always by the method of addition.

5.3 Upto twentyone-fold, the fire-altar is to be increased by the addition of one square *puruṣa.*

5.4 For (the purpose of) adding one (sq.) *puruṣa* to the original falcon-shaped fire-altar, a square equal (in area) to (that of) the original fire-altar with its wings and tail (i.e., $7\frac{1}{2}$ sq. *puruṣa*) is to be constructed and to it is added one (sq.) *puruṣa* (by the method of *samāsa.*)

5.5 The original fire-altar is to be divided into fifteen equal parts. Two of these parts are to be transformed into a square (by the *samāsa* method. This will give the (new) unit *(pramāṇa)* of the *puruṣa.*

5.6 One-fifth (of a *puruṣa*) is the measure for the *bṛhatī* brick and one-tenth (of a *puruṣa*) is for the *padamātrā.*

5.7 Or, an area of one square *puruṣa* is to be divided (into 25 parts) by (drawing) five lines both ways. Five of these small parts are to be transformed into a square, third part of which is cut off. The remaining (two parts) is added to one square *puruṣa*. This is another method (of determining the enlarged square unit).

5.8 One-fifteenth of a *puruṣa* is 8 *aṅgulas.*

5.9 5 *aratnis,* 10 *vitastis,* 120 *aṅgulas* are each equal to one *puruṣa.* One *pada* measures 12 *aṅgulas.*

5.10 Or, an area of one (sq.) *puruṣa* is to be divided by seven (lines) drawn from both sides; seven (parts) of these are to be combined (into a square); from this combined sum, (a rectangle) of $1\frac{4}{7}$ *aṅg*. by 1 *puruṣa* (to be transformed into a square) is to be subtracted (by the method of *nirhāsa*). The

remainder (which is a square) is added to one (sq.) *puruṣa*. This is another method.

5.11 By *aratni* and *vitasti*, no enlargement with *(puruṣa)* is to be understood; it is a number according to *Śruti* (i.e. enlargement of *puruṣa* is to be made with its submultiple).

6

6.1 As the (area) of the fire-altar is increased, so is (increased) the unit of the bricks. This we will explain.

6.2 The side of a square of area $14\frac{3}{7}$ (square) *prakramas* will give the unit in *prakrama* for 101-fold fire-altar (construction above twentyone-fold).

6.3 Or, in the second and following construction, there should be an increase (of one square) *prakrama* for every seven constructions.

6.4 (At each successive construction), instead of the (original) *prakrama* the value of the *prakrama* should be enlarged by its one-seventh.

6.5 Such (seventh part increase) is continued upto 101-fold fire-altar.

6.6 There should be no increase in the *antaḥpātya* and the *gārhapatya agni*. The *yoni* will remain (fixed), for, according to *Śruti*, (the number of) *yoni* never increases with the (number of the) birth. Accordingly, the increase of the *yoni* is prohibited.

6.7 The transverse (side) is to measure one less than the number of squares (of equal area) intended to be combined into a square ; the two sides (together) should be one more than that ; an (isosceles) triangle is to be formed (with the sides and the transverse side as the base); the altitude will produce it (the required square).

6.8 The increase of the altar depends on the distance between the poles *(yūpas)*. This we are going to explain.

6.9 The twentyfourth part of the cord measuring 11 *paravān* 10 *akṣa* (1172 *aṅg.*) of the chariot measure forms the (required) unit in *prakrama*.

6.10 Having constructed an altar with this unit (i.e. 1172 *aṅg.*), a (rectangular) portion of 12 *aṅgulas* from the east of the altar is to be cut off, and then having considered the east-west line are placed the poles in the holes (made for this purpose).

6.11 Or, the half (of the holes used for the two end *yūpas*) at both sides should be inside the altar (and the other half outside). This is according to *Śruti*.

6.12 According to another (group of teachers), the first and the last pole *(yūpa)* should be placed inside the altar ; this is natural.

6.13 It is an altar having a lock on the crown of the head *(śikhaṇḍinī vedi)*.

MANĀVA-ŚULBASŪTRA

1

1.1. Now we explain (the measuring with) a cord.

1.2. A cord of correct length with ties (at both of its ends) is stretched properly along the east-west line *(pṛṣṭhyā)*.

1.3. By the middle of a pair (of *nakṣatras*) Citrā and Svātī, Śravaṇā and Pratiśravaṇā, Kṛttikā and Pratikṛttikā, Tiṣyā and Punarvasu, having risen 86 *aṅgulas* (above the horizon), is (fixed) the eastern (cardinal) point, and it is (brought into a line) with the ties (of the cord).

1.4-1.6. (The cord) for the altar of the new and full moon sacrifice *(dārśikyā)* is 6 *aratnis* long, each *(aratni)* having the measure of 24 *aṅgulas*. The east-west line, east and west corners *(prāci*, *aṃsas* and *śroṇīs*) of the altar are fixed by means of drawing arcs with the help of a cord (marked) at 24 (= 7 + 17) *aṅgulas* and 8 (= 1 + 2 + 5) *aṅgulas*. The cord is (then) placed from south-east corner *(aṃsa)* to the south-western corner *(śroṇī)* and with this distance and with south-western corner as centre, is drawn an arc in the east. Having taken the centre of the circle at south-east corner, an arc is similarly drawn in the west. One end of the cord is now placed at this point of intersection and the portion from the south-east corner to south-west corner is cut off by means of drawing arcs. The same is repeated in the north, east and west.

1.7. The mound *(khara)* for the eastern fire *(āhavanīya)* is a square of one *aratni*, that for the western fire *(gārhapatya)* is in the shape of a chariot wheel *(rathacakrākṛti)* and that for the southern fire *(dakṣiṇāgni)* in the form of the half moon *(candrārdha)*.

1.8a, 1.8b. A circle is drawn from the middle (point of a square drawn for *āhavanīya)* with *koṭi* measure. With third part of the length which lies outside (the square) together with the original (inside) length (i.e., half of the side of the square) is described another circle (for *gārhapatya*). Draw another circle with the half of the square circumscribing (second circle). The half of this circle is it *(dakṣiṇāgni)*.

1.9. After having taken a cord equal to the distance between the *gārhapatya* and the *āhavanīya*, a mark is made at the third part of the other (i.e. western) end (and another at one-third distance from the east end). One-fourth of the middle part is left out (from the mark at the east). Now the terminal knots of the cord are fixed on (the two poles put on) the (two given marks) and the two cut ends are stretched towards south thereby assigning the (place for) the *dakṣiṇāgni*.

1.10. Having interchanged (the end-knots), the place of the northern pit *(utkara)* is fixed.

1.11. An extra length of a piece of cord is taken as long as its (original) measure. On the middle of the increased cord is given a sign for fixing the pole, and on the increased piece of the cord within this sign, a *nirañchana* mark is given at the middle

1.12. By this, the method of construction of all types of squares has been explained.

2

2.1. The pole *(īṣā)* is 188 *aṅgulas* long, the axle *(akṣa)* is 104 *aṅgulas*, the yuke *(yuga)* is 86 *aṅgulas*; this is the measure of the chariot of the Carakas.

2.2. After a mark is given at 188 *aṅgulas*, two marks are given at 6 and 9 and a tie is made at 43, the measures being in *aṅgulas*.

2.3. By this the altar for fastening animals *(paśubandha vedi)* for worshipping Indra and Agni is explained. This is measured with *ratha* units of the Carakas. The other *paśubandha* sacrifice has (a *prāci* of) 6 *aratnis*.

2.4. The (mark at) six *aratnis* is for *prāci*, at half an *aratni* is for *nirañchana*, then at half an *aratni* for *śroṇi*, and then at half an *aratni* the mark is for *aṃsas*. This is the measure of the *pāśuki vedi*.

2.5. From (one end of) the tie marks are given at 1/2 *aratni* for south-west corner, then at 2 *aratnis* for fixing it on the western point of the east-west line, then at 2 *aratnis* for north-west corner, then at 1½ *aratni* the *nirañchana*, then at ½ *aratni* (the mark) for the south-east corner, then at 1½ *aratnis* for north-east corner, then at 1 *aratni* for the (eastern) tie. The *māruti* and *varuṇa* altars are constructed with this cord.

2.6. The whole cord is 10 *aratnis* long, the *nirañchana* mark being at its middle. The mark for *prāci* must be at 5½ *aratnis*. This is used to construct a pointed *paitṛki vedi*.

2.7. The whole cord is 7 *aratnis*; the *nirañchana* mark is at its middle. The mark for *prāci* is at 5 *aratnis*. This gives the pointed *paitṛki vedi*.

3

3.1-3.3. The sacrificial hut *(prāgvaṃsa)* occupies (on the ground a square area of side) 10 *(aratnis)*; the hut for the wife *(patniśālā)* (a square) of 4 *aratnis*; the end of the *(mahā) vedi* is at a distance of 3 *(prakramas)* from the *prāgvaṃsa*; and the *sadas* is one *prakrama* away from the western end of the *(mahā) vedi*. The *(prāci* of) *sadas* is 9 *(prakramas)*. The *havirdhāna* (a square) of 12 *prakramas* is 4 *prakramas* from the *sadas* and 10½ *prakramas* from the *yūpāvaṭa*. One *pada* is allowed for the *yūpāvaṭa*, and

the remaining belongs to the *uttara vedi.* The *āgnidhra* hut is (a square of) 6 *aratnis.* The cord (required for this) measures 36 *prakramas.*

3.4. Marks are given on a cord of length 36 *(prakramas).* The marks for *(mahā) vedis, sadas, havirdhāna* are given (on the cords) at 15, 21, 3, 3 and then 12. At the *soma* sacrifice, the best construction is done with (a measuring) cord.

3.5. Where the length of a rectangle is 3 *padas,* and breadth 1 *pada,* its diagonal (squarred) will be 10 *padas* measured with a cord.

3.6. From a knot (at the end of a cord) used for the construction of the *sadas,* another knot is made at a distance of $13\frac{1}{2}$ *(aratni)*; the same technique is applied for (shorter) length of 9 *(aratni)*; this gives the best division for *sadas.*

3.7. Take a cord of 10 *akṣa* and 11 *padas*; the 24th part of this measure is stated to be also the measure for the *ekādaśinī* altar.

3.8. Wishing to construct the *śikhaṇḍinī (vedi),* $2\frac{1}{2}$ *(aṅgulas)* should be left from the end of the *mahāvedi*; $7\frac{1}{2}$ *aṅgulas* are known to belong to *devyavedi.* From the east this *vedi* looks like a lock on the crown of the head *(śikhaṇḍinī vedi).*

3.9. Five and seven *(prakramas)* and then one and one (less); this is called *kaukili vedi,* according to Caraka.

4

4.1. If the sacrificer be short by birth or through illness, what measures should be used by the priests ?

4.2. Six *tuṇḍas* made from the upper cover of a lotus stalk make one *bāla* of a three-year-old calf.

4.3. Three *bālas* of a three-year-old calf are equal to half of a mustard seed; two mustard seeds equal one *yava.*

4.4a, 4.4b. 1 *aṅgula* = 6 *yavas* placed side by side; 1 *prādeśa* = 10 *aṅgulas*; 1 *vitasti* = 12 *aṅgulas*; 1 *aratni* = 2 *vitastis*; 1 *vyāyāma* = 4 *śayā (aratni).*

4.5. A man *(puruṣa)* measures 120 *aṅgulas* according to his own limbs; but standing on his toes, he measures 125 *aṅgulas.*

4.6. 1 *kṛṣṇala* = 3 *yavas;* 1 *māna* = 3 *kṛṣṇalas* (berry); 1 *niṣka* = 1 *mānas.*

4.7. Altars are constructed with (square) bricks having sides one-third (40 *aṅgulas*) and one-fifth (24 *aṅgulas*) of a *puruṣa.* The half-bricks are prepared for fire-altars of three layers.

4.8. The (first) layer has eight by eight bricks, the second has eight by eleven; the layer should be placed alternately; the final layer has eight by twelve.

5

5.1. Now we shall explain the bricks required in future (construction).

5.2. A bamboo rod equal to the length of the sacrificer with uplifted arms (120 *aṅg*) is measured out.

5.3. A second (bamboo rod) equal to 144 *aṅg.* is taken up, and marks are given at 120 *aṅg.* (one *puruṣa*), 144 *aṅg.* (increased *aratni*), 132 *aṅg* (increased *vitasti*) and at the middle of 120 *aṅg.* (*puruṣa*) in each bamboo rod.

5.4. After clearing at the head, poles are fixed at each of the marks at two *puruṣas* and at their middle as in the case of a *pañcāṅgi* cord.

5.5. Two bamboo rods are then fixed at the middle poles and a sign is given at a distance of one *puruṣa* towards south, where these (rods) intersect each other.

5.6. A bamboo rod is fixed at the centre pole and held over the sign towards south; then a pole is fixed at a distance of one *puruṣa.*

5.7. The second bamboo rod is fixed at the eastern pole (on the head) and held towards south from east; poles are fixed at the distance of one *puruṣa* and also at their middle; the same is repeated in the west.

5.8. By this the northern half is (also) explained.

5.9. At the middle poles on the southern side of the square (thus formed), two bamboo rods are fixed and held towards south, and a sign is given at a distance of one *puruṣa*, where these (rods) intersect each other.

5.10. A bamboo rod is then fixed at the centre pole (on the southern side of the square) and held over the sign towards south; then a pole is fixed at a distance of 144 *aṅg.*

5.11. The bamboo rod measuring 144 *aṅg.* is then fixed at the middle pole on the eastern (half of the southern side of this square) and held towards south, and a mark is given at a distance of 144 *aṅg.*; therefrom towards west a pole is fixed at (a distance of) 60 *aṅg.* Likewise, (from the middle pole) on the west.

5.12. (In the same manner) the construction of the northern wing is explained.

5.13. For (the construction of) the tail, *vitasti* should be used in place of *aratni* (that is, marks should be given at a distance of 132 *aṅg.*).

5.14. The head lying eastward of the eastern side is to be measured by half *puruṣa* of the *pañcāṅgi* rod.

6

6.1. For the *gārhapatya* fire-altar, the bricks should be constructed with sides o ne-eighth of a *vyāyāma* and one-fourth of a *vyāyāma* (i.e., 12 *aṅgulas* × 24 *aṅgulas*) and with both sides one-fourth of a *vyāyāma* (24 *aṅgulas* × 24 *aṅgulas*).

6.2. The first type of square bricks is to be made with each side one-tenth of a *puruṣa* (i.e., 12 *aṅgulas* × 12 *aṅgulas*); the second type (rectangular) with sides one-tenth of a *puruṣa* and one-half of (this tenth) *puruṣa* (i.e., 12 *aṅgulas* × 6

aṅgulas); the third type (rectangular) with sides one-tenth of a *puruṣa* and one-tenth increased by its half (i.e., 12 *aṅgulas* × 18 *aṅgulas*); and the fourth type (square) with both sides one-fourth of a *puruṣa* (30 *aṅgulas* × 30 *aṅgulas*).

6.3. Their height is one-fifth of thirty *aṅgulas* (i.e., 6 *aṅgulas*); but the height of *nākasat*, *cūḍā* (fire baked), and *ṛtavyā* (seasonal) bricks, used in the middle (layers), and of *vaiśvadevī* bricks used in fifth and sixth layer, is half (of the former set of bricks).

6.4. Loose earth is placed in the space between bricks so that these are bound together and not separated.

6.5. These materials are placed in the holes for the (grouping of) bricks.

6.6. The verse runs thus : 'The pits are dug for keeping the vessels, the heads of animals, tortoise, wooden mortar, two wooden spoons, pitcher and bricks, and for walking (of person in attendance).'

6.7. (The bricks) are to be placed in all directions within the body, at the juncture of head, tail and two wings, facing towards east, north, east to west, south to north and dividing them equally; depending on the contents, four bricks are to be placed towards east and five towards west of the seasonal bricks and half (of these bricks) towards north-eastern side of the *gārhapatya* fire. The rest (of the fire-altar) is covered with square bricks (12 *aṅgulas* × 12 *aṅgulas*).

6.8. The same method from south to north is followed in the second layer, the remaining area being covered with square bricks.

6.9. What is done in the first layer is repeated in the third and the fifth, and the arrangement in the second layer is repeated in the fourth; alternate layers (of the fire-altar) are laid in accordance with these directions.

6.10. Then in the (case of) *āgnidhriya* and (similar) other constructions, the area should be divided into nine equal parts. In the *āgnidhriya,* a stone is placed in the middle; in the *hotrīya,* (middle portion of) each side is covered with four *turīya* bricks (30 *aṅgulas* × 30 *aṅgulas*); in the *brāhmaṇācchaṃśa* (hearth), four half bricks are placed in the corners; in other types of fires such as the *mārjālīya* and the *paśu-śrapana* (the butcher's fire), six *adhyardhā* bricks (18 *aṅgulas* × 12 *aṅgulas*) in twos with the *prācī* in the middle, are used.

6.11. Twenty *adhyardhā* bricks (18 *aṅgulas* × 12 *aṅgulas*) are placed eastwise in the two *aṃsas,* twenty in the two *śroṇis* and in the tail, twelve bricks on the eastern side of the two wings, turned towards east and west, and five bricks on both sides of the head; the remaining (area) is filled with square bricks (12 *aṅgulas* × 12 *aṅgulas*). This is the first layer.

6.12. In the second layer, twenty (*adhyardhā* bricks: 18 *aṅgulas* × 12 *aṅgulas*), turned in the direction of north-south and south-north, are placed at the *śroṇi- aṃsa-pakṣa* portion of the fire-altar; eleven on both sides of the tail; and five turned towards east on either side of the head; the remaining (area) should be covered with square bricks (12 *aṅgulas* × 12 *aṅgulas*).

6.13. What is done in the first layer is repeated in the third and the fifth, and the arrangement in the second layer is repeated in the fourth; alternate layers are laid in accordance with these directions.

6.14. In the three-day worship, two (layers) are constructed on the first day and three on the second day (covered with loose earth on the third day); in the six-day worship, one (layer is constructed) each day (covered with loose earth on the sixth day); and in the twelve-day worship, the construction should be made with one layer of bricks and one layer of loose earth on alternate days.

6.15. By following this method, the construction is made throughout the whole year.

6.16. (The bricks are placed) while reciting the *mantras* at the beginning and then touched at the end; that is the characteristic of a *puruṣa.*

7

7.1. A bundle of *darbha* grass, a lotus leaf, two idols of gold, a gold brick, a pebble, *svayamātṛṇṇa* (brick), *dūrvā* bricks (with engraving of *dūrvā* grass) and rice-gruel, —all are placed in the middle; towards east and in the middle of five cornered space are placed *svayamātṛṇṇa* (bricks); in the middle, north, south, *sruca* and *kumbheṣṭakā* bricks; the remaining bricks are placed in the holes to the west side of the *svayamātṛṇṇa* (bricks); the west like (brick), a brick consecrated with *mantras,* towards north of the one of the first interspace; a brick connected with their sides and a brick consecrated with *mantras* towards north; then in the east two seed-pourer *(retaḥ sica)* bricks; in the southern interspace a *ṛtavyā* and a *dvitīyā* brick and in the east at the fourth place the seed-pourer *(retaḥ sica)*; a brick embodying cosmic light (*viśvajyoti*), a circular (brick), a seasonal (*ṛtavyā* brick), and *dharma, aṣāḍa, kūrma* and *bṛṣa* bricks are placed; and that is the end (of construction) towards east. In the northern interspace towards the south-east are placed *svayamātṛṇṇa* bricks from the east; to the east the mortar and the pestle; and near the head to the north-east within it is placed one vessel *(ukhā)*.

7.2. To the west (of *ukhā*) the *puruṣaciti* with its head measuring one *puruṣa* is constructed with thirty-six bricks in the west and nine (bricks) on the *śroṇi.*

7.3. So runs the verse : "Three (bricks) are placed on the neck, six on each of the two shoulders, two on each arm, nine on the body, five on each leg in the west, and one on each hand and foot."

7.4. After having equally divided eight *apasyā* bricks, in each ninth interspace is placed *prāṇabhṛt* (brick); in the north-eastern interspace first set (of ten); in the south-western second set (of ten); in the south-eastern (the third set); in the north- western (the fourth set); in the second interspace towards south of the *svayamātṛṇṇa* the fifth set of ten; in the ninth interspace the supersized joined brick like that of the *prāṇabhṛt.* In the south-eastern interspace is

placed the first (set of ten); in the north-western (the second); in the south-western (the third); in the north- eastern (the fourth); in the second interspace towards north of the *svayamātṛṇṇa* the fifth (set of ten); the *vaiśvadevi* (bricks) are placed near each quarter towards north-eastern interspace, towards south and north in the junction of the wings and their two interspaces towards east of the head of the Atharvan.

7.5. The head, two wings and the tail are divided into equal interspaces and then the first region (for first interspace) is fixed.

7.6. In the first interspace on the head, *loka* bricks are placed side by side; likewise in the fourth interspace of two wings along east and of the tail along north; towards west of the *svayamātṛṇṇa* are placed bricks which had been previously joined side by side; in the southern interspace are placed *vaiśvadevī* bricks, and the northern interspace (is filled) with loose earth.

7.7. In a large sacrifice, procedures, as known through sacred texts, are followed with (chanting of) *gāyatrī* and *rathantara* hymns of praise in the construction of the head.

8

8.1. In the second layer towards east of the *svayamātṛṇṇa* are placed *ṛtavyā*, *vāyavyā* and *apasyā* (bricks), in required number, in the first, second and third interspaces respectively. In the southern interspace are arranged the sets of three bricks (*ṛtavyā*, *vāyavyā* and *apasyā*) from south to north; (another) sets of two bricks (*ṛtavyā* and *vāyavyā*) (are placed) on both sides north of the ninth (interspace); the remaining space is covered with *apasyā* bricks.

8.2. In the (construction of the) third layer, ten *(prāṇabhṛt)* and twelve *(bṛhati)* bricks are placed on both sides of the ninth interspace; seven square *(samici)* bricks are arranged in the east, seven in the west and eight half bricks *(ardhotsedhā)* consecrated with *mantras* on both sides of the *svayamātṛṇṇa* in the eighth interspace or in the last *(uttama)* layer.

8.3. In the fourth layer, the first (*ṛtavyā* bricks) are placed first on both sides of each of the ninth interspace. From the east to the middle of the northern interspace side by side; in a similar way (are placed) the *spṛta* (bricks in excess) from the east to the middle of the southern interspace alternately. In the sixth, seventh and eighth (interspaces) are placed seventeen groups each containing a pair (of bricks) and in the south fifteen groups each containing three bricks in the north.

8.4. In the fifth layer, one *prāṇabhṛt* on each of the (fire) places; *chanda* and *virāja* (bricks) in the remaining places, similar to *atimātrā* bricks in excess in the sixth, seventh and eighth interspaces as many as are required.

8.5. After having covered with half bricks, half *stoma* bricks (or portions) are placed from the south to east, a pair of bricks in the west, and a group of three

(bricks) in the north; these make a total of thirty-one bricks. Also a group of three (bricks) are placed by (the sides of) *nākasadas* in the west. It is then covered with loose earth, *yava* etc. and by the required number of bricks with names sprinkled with clarified butter. Then the *turiya* (bricks) (are placed) in the middle in the same manner as the *prāṇabhṛt* and the *atimātrā;* in the north, one *vikarṇi* (is placed) in the middle with *svayamātṛṇṇa.*

8.6. This is about (the construction of) the *suparṇaciti.*

9

9.1. The decrease (in shape) suffered by the bricks due to drying and burning is made good by further addition so as to restore the original shape.

9.2. The decrease is always by one-thirtieth part of the original; hence the same is to be added to have the original shape.

9.3. A brick of 150 (sq.) *aṅgulas* decrease by 6 (sq.) *aṅgulas;* the area of the brick other than this is deformed (or not natural).

9.4. The *(gārhapatya)* fire-altar measures 9216 (sq.) *aṅgulas;* the measure for *aṅgula* and *vyāyāma* is to be determined.

9.5. The area of each hearth *(dhiṣṇya)* is fixed at 1196 (sq.) *aṅgulas.*

9.6. The area of the fire-altar *(agniciti)* is 111600 (sq.) *aṅgulas.*

9.7. The original or derived area is $7\frac{1}{2}$ (sq. *puruṣas*); then area for head being 25 (sq. *pada* = $\frac{1}{4}$ sq. *puruṣa*) is added to it.

9.8. The area is also 800 less 1 *pada* (799 sq. *padas*); the *kṣetravid* knows what the area of the limbs together with that of the head of the altar should be.

9.9. The body is to be made of 400 (sq. *padas*); each of the two wings of 120 (sq. *padas*); the tail of 110 (sq. *padas*); and the head of 25 (sq. *padas*).

9.10. Thirty-one, thirty-three and fifty square bricks are placed; half bricks are considered for non-square places.

9.11. In the placement of hundred bricks, where there is shortage or increase of area, the intelligent (person) must use broken bricks consecrated with *mantras.*

9.12. The bricks for the wings, the tail and the head are placed on the square *pṛṣthā;* where the space exists, that is vanished.

9.13. The placing (of bricks) for the *rathantara, bṛhalloka* and *gāyatra yājñiya* is remembered by heart and done wisely.

9.14. The number of bricks used (in the construction of) *yayuṣmati* is always fixed; the number of bricks used in each layer *(citi)* is being discussed; listen.

9.15., 19.15a. There are, according to experts, 186 (bricks) in the first layer; and 80 (bricks) in the second; 113 (bricks) in the third; 104 (bricks) in the fourth; and 356 (bricks) in the last layer.

9.16. By all these *yajuṣmati* layers the fire-altar (the *agni*) is produced; lastly, it is plastered with loose earth.

9.17. By this, the *yaju* (*ṣmati* layers as quoted) are constructed; there are thousand (bricks) to be laid with (the use of) sands.

9.18. The fire-altar suitably constructed is like a cow that is produced; the sacrificer milks always (from this) the desires for the *yajamāna*.

9.19. He who knows sixty Prajāpati (lords) as *saṃvatsara* goes to the heaven *(brahmaloka)*, the firmament and the abode of the sun.

10

10.1a, 10.1b. According to the *vaiṣṇava* (measure), the geometrician, the calculator, the dictator, and the one who has taken up measuring as profession are always honoured by the *śulbavids*. The construction (of the altar) is effected by dividing the earth which has been measured by us (since it belongs to us); the best measure for sacrifice is obtained when the construction is done in one's own house.

10.2. The ground should be plane (or level), the *śaṅku* straight, and the cord (made of *muñja* grass) be free from knotch (or be smooth). There shall be no construction in the beginning of the *nakṣatra citrā;* this is done when the *tithi* and *nakṣatra* are in good accord with water *(varuṇa)*.

10.3. The breadth of all (altars) should be towards east; the altar should be made after the body of the *yaska*; the height of that altar is equal to *arva* (16 *aṅgulas*); and the cutting (of the altar) containing five layers should be at the knee *(iānu)*.

10.4. In the second layer are placed half of *ṛtavyā*, *nākasat* and *pañcacoḍā;* the area for the construction of the altar is 7½ (sq.) *puruṣas*.

10.5. The (construction of the) *havirdhāna* is completed by a container, of the mound by means of pots, of the *cātvāla* by animals and of the mound with fire by materials of the sacrifice.

10.6. The half circle of area 1 (sq.) *aratni* is (transformed) into a four-cornered mound; by following different methods its volume in *aratni* is found.

10.7. Having drawn a line equal to 24th part of a *puruṣa* in the east, another line of equal length is drawn in the west; towards south is drawn sixteen *(aṅgulas)* and towards north thirty *(aṅgulas)*.

10.8. The *cātvāla* is made one *prakrama* towards east; and the place for immolation is the same as one *prakrama;* the (area of) the *cātvāla* is to be increased depending on the increase in the number of animals.

10.9. Multiply the length by the breadth separately and that again by the height; this always gives the result in cubic measure.

10.10. Multiply the length (of a right-angled triangle) by the (same) length and the breadth by the breadth; the square-root of the sum of these two (results) gives the hypotenuse; this is already known to the scholars.

10.11. (There shall be no construction) with (the use of) fire and water in *śravaṇā* and *abhijit, bahulā* and *tiṣya, citrā* and *svāti.*

10.12. The *prāci-bhāskara* is to be protected in the night; this is found as the east-west line by means of a *śaṅku* set up in a circle.

11

11.1. If the sacrificer be diseased or short (in height) from birth what should be the measure to be used by the priests in this case?

11.2. A thick cord of hair, a mustard seed, and a *yava,* (each) six times of previous one; one *prādeśa* is to be equal to 12 human *aṅgulas.*

11.3. Two such *(prādeśas)* make one *aratni;* one *prakrama* is equal to one *aratni;* that *(prakrama)* is considered to be two *prādeśas* for purposes of measurements of a fire-altar.

11.4. A measure of four *prakramas* is always less by $1\frac{1}{2}$ *aṅgulas.*

11.5. There are eleven *yūpas,* four increased with four at each sacrifice.

11.6. In some altars there are two fires with no use of bricks. If the altars are constructed separately, the fires are so constructed.

11.7. One hundred and twenty *aṅgulas* of a man always equal his five *aratnis* or ten *padas;* depending on the man's stature, the measure may be smaller or larger.

11.8. Eighty-six *aṅgulas* are known to be equal to one *yuga;* one *akṣa* measures eighteen *(aṅgulas)* more (i.e., 86 + 18 or 104 *aṅgulas*); all *ratha* measures are done as per prescriptions of the texts.

11.9. Now begins the (method of) construction of a circle. Having desired to construct a circle out of a square, the (following) method has been enunciated by the experts; listen to it.

11.10. The line joining the point of intersections of triangles formed in a square (that is, the point of intersection of two diagonals) and the corner (of the square) is stretched towards east; that (which remains inside the square) together with one-third (of the part projecting outside the square) forms the radius of the circle.

11.11. One *puruṣa* (measure) produces a square of one *puruṣa;* its diagonal produces (a square of) two *puruṣas;* the diagonal of this (second square) produces (a square of) four *puruṣas* or two *puruṣas* produce a square of four *puruṣas.*

11.12. One side (of a right-triangle) is two *puruṣas,* the other side four *puruṣas;* two rectangles, each having two such triangles make as quare of sixteen (square) *puruṣas.*

11.13. The fifth part of the diameter added to three times the diameter gives the circumference (of a circle). Not a hair of length is left over.

11.14. Divide the diameter of a circle into ten parts and leave out three parts. The square drawn with this (as side) and placed within the circle projects outside.

11.15. Divide the square into nine parts by drawing three (parallel) lines from two sides; drop out the fifth portion (in the centre) and fill it up with loose earth.

11.16. A man measures four *aratnis;* for construction with sand, the use of half-arm (i.e., one *aratni* extra) is also considered.

11.17. The sides (of a right triangle) are made with 3, 4 and 5; those of others are made by multiplying (these numbers) with desired (quantities), as may be required in the (construction of) altars; this has always been prescribed by ancient teachers.

11.18. For round lines (in altar), the measurement of layers are done by a multitude of measures and their changes; the measures are calculated by length and breadth.

11.19. The (unit of) double the measure of length is found from a (newly) constructed square or from a five-joint cord *(pañcāṅgī)* or as explained by the ancient teachers.

11.20a. 11.20b. Here is the method of construction with a five-joint cord; with this the measurement of all altars with the exception of *kaṅka* and *alaja* is done; I shall explain the markings (in the joints of such a cord).

11.21. A cord of double the measure, with marks at both ends, is given a mark at the middle, then another mark at one fourth (of the second half) which is *nirañchana* and then another mark at the middle (of the second half); the distance (from the *nirañchana* mark to the end of the second half) is equal to breadth; (with this) the required square (is constructed).

11.22. The east-west line *(prācī)* then becomes equal to the length of the original measure; two ties are given on (the ends of the) (increased) cord, and a pole at the middle.

11.23. After fixing the western end of the cord at the middle (pole) the cord is stretched towards east-south corner by the *nirañchana* mark and a pole is inserted at the middle (of the second half); the same is repeated towards (south-)west, and in (the north of) the middle; this is done in the *vāsuvedi.*

11.24. The ties should be lifted up for the measurement of the western corners.

11.25. Draw (straight) lines from *aṃsa* and *śroṇi* in the direction of each; with *aṃsa* and *śroṇi* (as centres) and distance between them (as radius) draw lines

(such that these intersect); fix poles at the points of intersection; with these (as centres) and with the same radius (as before) draw curves on both sides.

11.26. When it (the altar) contains bricks, no line should be drawn in the remaining two sides (east and west).

11.27. At the eastern and western third post the rubbish heap and the southern fire *(dakṣiṇāgni)* are correctly placed.

11.28. Other parts are drawn from the middle (line) with nine *aṅgulas.*

12

12.1. The half measure lessened by its sixth is known as the *viśeṣa.* The *viśeṣa* and the measure *(pramāṇa)* produce the diagonal of the measure.

12.2. Take the other half of the measure; increase its (measure) by its twenty-fourth part and give at this a sixth knot with a mark, known as *nirañchana,* (used) for diagonal; the remaining (part) is the transverse side *(tiryaṅmāni).* The *śroṇi* is half-hand away from the knot.

12.3. It has been advised for (obtaining) the *āgnidhra.*

12.4. That which is the diagonal of (one-fold) fire-altar is, with the original, the diagonal; in this way the twentyone-fold *aśvamedha* fire-altar is obtained.

12.5. (The length of) 1 *puruṣa* and (the breadth of) $\sqrt{10}$ *puruṣa* produce an area of 11 (sq. *puruṣas*).

12.6. The diagonal formed of two sides each having the length of 1 *puruṣa* is not smooth (not an integral number). The fire-altar from 1 to 101 fold has been achieved by increasing its side (as discussed in 12.4.).

13

13.1. In right-angled triangle also (vide 12.4.), the hypotenuse of $\sqrt{16}$ *aṅgulas* will give value in *prakrama* for the *sautrāmaṇi* sacrifice.

13.2. One-third of a *prakrama* (i.e., 10 *aṅgulas*) is for (the construction of) the *saumiki,* the queen of the serpents *(sārparājñiki).* This with $\sqrt{3}$ and other with $\sqrt{3}$ serve the purpose of the altar previously mentioned.

13.3. In the *soma* sacrifice, one *prakrama* equals 14 *aṅgulas* or it should be measured with 1200 (sq.) *aṅgulas* as in the case of the animal sacrifice.

13.4. Give a mark at one-fourth; draw circles with one-sixth, one-ninth, one-seventh and one-ninth, and in (each of) half side; there shall be no circle (in the west).

13.5. The *sāvitṛ* and similar altars should be constructed in four days; the *aruṇa* (altar) should be made knee-high and filled with water.

13.6. The *gārhapatya* (fire-altar) has two forms e.g., the square and the circle; the square is constructed with a side of one *vyāyāma* (i.e., 96 *aṅgulas*) and the circle with a radius of half *puruṣa* (i.e., 60 *aṅgulas*).

13.7. The (rectangular) bricks having length one-third of a *vyāyāma* and breadth one-seventh of a *vyāyāma* are to be made and (arranged) in the first and in other alternate layers (each) with 21 bricks.

13.8-13.9. Rectangular bricks (used in other layers) are one-third of a *puruṣa* long and one-sixth (of a *puruṣa*) broad; its breadth of one *prathika* (20 *aṅgulas*) is arranged along the length (of the altar), the breadth and the length of the middle and the remaining layers being equal. The two bricks each of 20 *aṅgulas* at the two corners equal the length of the brick (i.e., 40 *aṅgulas*); (by this arrangement) the cleavage (is prevented). Three corner bricks (of each layer) are replaced by six half bricks (to make each layer of 21 bricks).

13.10. (Here have been used) a number of four-sided bricks measuring more than a *prathika* by one *prathika*.

13.11. In the circular *(gārhapatya)*, there are four kinds of bricks measured with the parts (of a *puruṣa)*.

13.12. Four (square) bricks are placed in the middle; two more (such bricks) to the east and west of them; two each on the sides; then one of the bricks looking like half-moon is divided into two half bricks; the remaining circular parts are equally divided; thus 21 bricks (are made).

131.3. Alternate layers are done with bricks facing north.

13.14. Types of bricks used (for fire-altar) together with the chanting of the *gāyatra* (metre) include one-and-half, quarter, half-quarter and the fifth of a *puruṣa* (*padyapāda* or *pañcamī*).

13.15. Taking a cord two *puruṣas* long and four times the original cord, marks are to be given at equal intervals by an expert; this is known to be *pañcāṅgī* by the learned.

13.16. From the middle (of the cord) between ties marks are given at (a distance of) one *puruṣa* increased by one *aratni;* this is called the *gāyatra* measure and used for the construction of a square; at the end each wing is increased by the *gāyatra* (24 *aṅgulas*) measure and the tail by what is left after taking off 108 *aṅgulas* (from a *puruṣa*).

13.17. When dried and burnt, bricks (usually) lose one-thirtieth (of their size).

13.18. Then after a place is washed with water and sanctified, it is divided into three or four parts.

13.19. *Adhyardhā* bricks (18 *aṅgulas* × 12 *aṅgulas*) are placed,—20 on the north and the (southern) *aṃsa* of the *prāci*, 10 in the tail (on each side), 12 on each side of both wings, and 5 on both sides of the *prāci*. The number of bricks are 15 on the head, 84 in the two wings, 85 on the body and 30 on the tail. According to some scholars, there are 99 quarter bricks in the tail, 20 each in *śroṇi* and *aṃsa*, 10 on each side of the tail and the wings.

13.20. (In the second layer) ten *adhyardhā* bricks are placed in the head towards east and north.

13.21. Bricks in the first (layer) are connected together and turned towards east and those of the second are connected by *mantras* and intended for *aśvini.*

13.22. The piling of bricks is done by alternating (the above layers) upto the height of the knee.

13.23. For a small area of (side) 3 *padas*, the *dhiṣṇya* (fire) of one layer is to be constructed with 4 kinds of bricks; for more layers it is done with *mantras* concerning the fire-altar.

13.24. There are 4 *adhyardhās* (18 *aṅgulas* × 12 *aṅgulas*), and the two in the middle are to be (divided into six parts) *(nakula caturbhāga)*.

13.25. In the *āgnīdhriya,* a stone is placed in the ninth place (i.e., in the middle).

13.26. Then we shall explain the *hotriya*. The two *nakula* bricks of *pada* measure (12 *aṅgulas* × 12 *aṅgulas*) on the two *aṃsas* and *śroṇis* are divided into four quarter bricks giving 14 bricks in each of the triangular directions. In each direction there are 8 quarter bricks.

13.27. In the *brāhmaṇācchaṃśa,* there are 11 bricks in the middle, two sets of quarter bricks and a *nakula* brick (12 *aṅgulas* × 12 *aṅgulas*).

13.28. There are three quarter bricks (12 *aṅgulas* × 12 *aṅgulas*) on each side and two *adhyardhā* (18 *aṅgulas* × 12 *aṅgulas*) bricks in the middle,—in all eight bricks.

13.29. Six *adhyardhā* bricks (18 *aṅgulas* × 12 *aṅgulas*) are placed on the *mārjāliya;* its *aṃsa* is situated in the southern side of the *(mahāvedi)* for cooking of sacrificial flesh. In the west, three bricks of 12 *aṅgulas* × 36 *aṅgulas* are placed for washing the vessel with water after the sacrifice is over.

14

14.1. In the *śyena* (fire-altar) there are 37½ parts in the left wing, 4 in the head, 26 in the body, and 15 in the tail. The *alajacit* has 17 (parts) in the tail, 2 in the head, and the same (number of parts) in the body and the (two) wings (as in the *śyena*). These are measured by (bricks of side) one-fourth of a *puruṣa* intermingling the joints of the parts.

14.2. In the *kaṅkacit,* 8 parts are in the tail, 4 parts in the feet and 7 parts in the head; the body and the two wings have the same (number of parts) as in the *śyena.*

14.3. In the construction of *śyena, alaja* and *kaṅka* (fire-altars), 8½ parts are spread out in the tail, 4 parts in the body, 2 parts in the head and 5 parts in each of the wings.

14.4. In the *śyena, alaja* and *kaṅka* (fire-altars), two-cornered, three-cornered and four-cornered (bricks) are used in the tail. The five (bricks used) at the ends of the wings are those obtained by cutting (the original bricks) by the diagonal.

14.5. Two parts are added to the tail in the *alaja* which is filled up by three-cornered (bricks); three parts are transferred from the tail of the *śyena* to the head of the *kaṅka,* and two parts are again cut off (from it) for each foot of the *kaṅka.*

14.6. 12½ parts are measured along east, 20 in north; 15 parts for *kaṅka* and 13½ for *alaja* in the north.

14.7. A cord (for the construction of *vakrapakṣa śyenacit* and others) should have 12 parts or 12½ parts; a mark is given at its middle and that for the *nirañchana* at one-fourth (of the second half).

14.8a. 14.8b, Marks are given (in the cord) first at part 4, then at 5½; in another (arrangement), in the middle and at parts 8, 9, 10 and 11½.

14.9. Then it is stretched on the *prācī* (line) and a pole is fixed at (each of the marks at) the middle of the two (end) ties, and at 8 and 4. Fixing the (eastern) tie at (the pole at) 4, the cord is stretched (by the middle) and the *nirañchana* mark is given at the middle.

14.10. (The cord is) again stretched from the middle pole (after fastening the tie at it) and a mark is given at 4 parts. The cord is similarly stretched on both sides of the pole at 10, marks are given at parts 2 and 4, and then (a place is fixed) in the east at 5½ parts. Poles are inserted at four places at equal distances apart.

14.11.14.12. Then the cord is stretched on the east-west line with ties at the pole, at 5½ (part); (again) stretching it at the two western poles, two poles are fixed at 7½ and 8, and at 4 and 9.

14.13. A tie is fixed at pole 8 (middle pole of the second east-west line), and the cord is stretched by keeping (the end tie) fixed at the pole 8 (middle of the third east-west line), and two poles are fixed at parts (10 and 11½ not inserted before).

14.14. (Having) fixed the tie at the first two poles, the cord is stretched by the pole at 8, (then) a pole at 10 gives the middle of the tail of *alaja.*

14.15. A tie given at mark $11\frac{1}{2}$, is fixed at the third middle pole and stretched by the mark at 3; again a tie at 2 is stretched by the mark at 10; and poles are inserted at these two marks; the same is done in the northern (wing).

14.16. The mark at 2 is fixed at the northern point of (wing) and is brought to the south after stretching it into two equal parts.

14.17. A pole is fixed at the fourth part (from eastern *aṃsa* point), and the operation is repeated in the opposite manner. For this (purpose), the cord is stretched from the fourth part.

14.18. The pole is to be fixed at $7\frac{1}{2}$ part in the case of the *kaṅka (cit)*; this is known.

14.19. Having given a tie at mark 3 (of the cord) and fixed it (in the pole at 8 i.e., the middle pole), the cord is stretched by (the mark at) 10, and two poles are fixed at these two marks. The same is done in the northern (wing).

14.20. This is the cord with 12 marks (used for the measurement of area) of the *śyena* (fire-altar).

14.21. Four kinds of bricks are prepared with one-third and one-fourth (of a *puruṣa*). These are one-ninth of the original (40, 40), triangular (30, 30, $30\sqrt{2}$), half-triangular ($15\sqrt{2}$, 30, $15\sqrt{2}$) and five-cornered bricks ($15\sqrt{2}$, $15\sqrt{2}$, 15, 30, 15).

14.22. Two five-cornered and two half-triangular (bricks) are placed on the eastern (side of the head). One each (of these bricks) is placed at the top of each *aṃsa* and at the top of each wings in both sides.

14.23. The middle of the body is filled with one-ninth (square) bricks surrounded by triangular bricks; five triangular bricks are placed in the end of (each) wing.

14.24. Two of the triangular bricks are placed oppositely in the joints between the body and the tail, together with (two) five-cornered bricks at each of the west side; in the joints between the head and the body are placed half-triangular bricks, and the head is likewise filled up with these (half-triangular bricks).

14.25. Two half-triangular bricks are placed on the joints of the wings (one at each western corner), two at the junctions of the tail, fifteen at the tip of the tail, and twentyone at the end of each wing.

14.26. The construction of the falcon-shaped fire-altar is thus completed by using cords of shorter and longer units for the measurement of its area and by (the arrangement of) bricks in alternate layers.

14.27. The wing of the *alaja* (fire-altar) is not bent; such is done in the previous layer; the tail is worked out from the middle with cord used in (the measurement of) *śyena*.

14.28. Two poles are fixed on the ninth part from the eastern point; construct a triangular brick (15, 15, 15 $\sqrt{2}$), being one-fourth of a square brick (30, 30); this is so in the *alaja* due to half of its wing being not bent.

15

15.1,15.2. The same as 4.7 and 4.8, being repetition.

15.3. The fire-altar in the form of an isosceles triangle *(praugacit)* has an area one half of 15 (sq.) *puruṣas*. Join the middle (of the eastern side of the rectangle of area 15 sq. *puruṣas* and sides 20 *aratnis* and 19 *aratnis*) at 10 *(aratnis* from either end) with the north-western and south-western *śroṇi* (points) to form a triangle; the bricks are accordingly made.

15.4. In (the fire-altar in the form of) a rhombus *(ubhayatā prauga)*, there are 21 squares (each of side 72 *aṅgulas*); half of it lies opposite to each other; the two *aṃsas* and *śroṇis* are cut off so as to form an isosceles triangle on either side (of the common line).

15.5. The *samūhya* fire-altars are (built) without bricks in the (four) cardinal directions; *cātvāla* pits are constructed in four sides and are dug for waste products; this has been prescribed.

15.6. A fire-altar in the form of a pyre *(śmaśānacit)* should be drawn in the form of a circle or a square. In the fire-altar in the form of a trough *(droṇacit)* there is a handle *(tsaru)* which has an area one-tenth of the original (fire-altar).

15.7. (For the circular *droṇacit*) a square is drawn within a circ'e as in the case of the *gārhapatya* altar; it is measured with one-twentieth part (of the square drawn on 72 *aṅgulas*); for the *varuṇa* (altar) it is done with half-part.

15.8. After the area inside and outside (the squares) is measured, it is divided into ten equal parts (by means of ten parallel lines from each side); there should be a triangle in the corner and joints in alternate layers.

15.9. Each brick used in the square has an area one-thirtysecond ($\frac{1}{32}$) part of the square (of side 72 *aṅgulas*) (i.e., 162 sq. *aṅgulas*); the bricks of one and half times *(adhyardhā)* are also made; these are like the *gāyatra*.

15.10. (For the *droṇa* fire-altar) of 1,000 bricks, each brick must have an area of one-fifteenth part of the square (of side 72 *aṅgulas*); bricks of one and half times *(adhyardhā)* are also made; then each layer is known to have 200 bricks.

15.11. (In a construction of thousand bricks), there are 250 one-and-half bricks *(adhyardhās)*, 150 square bricks, and out of 1,000, one-hundred (is always used) for wings of each layer.

15.12. Each of the bricks (used in the second and fourth layer) has an area of one-thirtyfirst part of the square (of side 72 *aṅgulas*); one thousand square bricks are placed altogether.

15.13. The circular (fire-altar in the form of a) chariot wheel *(rathacakracit)* covers an area of $10\frac{1}{2}$ (square) *puruṣas*; it has nave, spokes, and empty interspaces between the spokes and the rim accounting for the excess (area).

15.14. (Each of) twentyfour (spokes and interspaces) covers a rectangular space of length one *puruṣa,* and breadth $\frac{1}{8}$ *puruṣa*; these cover (a space of) 3 *puruṣas*; half of this space is used for spokes (since half of the interspace is left out).

15.15. Now I shall explain the making of the interspace; the side on the rim is $\frac{2}{7}$ *puruṣa* (i.e., 34 *aṅgulas* roughly); (the length) is $\frac{1}{8}$ (sq. *puruṣa*) (i.e., 92 *aṅgulas* roughly); it is placed on the nave at an interval of 24th part of a *puruṣa* (i.e., 5 *aṅgulas*); from that 8th part, it will be formed in the shape of an isosceles triangle *(prauga).*

15.16. The nave is constructed with two bricks; the spokes are made of four, and the felly of three and their parts; the alternate (parts of spokes) are hollow.

15.17. To measure the interspace of the nave, a circle is constructed with one-fourth of the diameter, i.e., with 43 *aṅgulas,* and that of the rim with 62 *aṅgulas.*

15.18. The remaining layers are done with reason and right proportion.

15.19. He who follows traditional methods and measurements appeases hell and goes entirely to a world with makers of *śulbas.*

16

16.1a. 16.1b. Another type of fire-altar in the form of a chariot-wheel *(rathacakra),* as explained by Viṣṇu, is to be piled up by the performer; it is three times as large and $7\frac{1}{2}$ (sq.) *puruṣas* are embedded in its circle by the learned.

16.2. An interspace of 3 more (sq.) *puruṣas* is left out from the specified area.

16.3. Its rim (becomes equal to) the breadth of spokes, and the diameter of the circle and bricks used are made by the third part.

16.4a. 16.4b. The nave is drawn with $\frac{1}{2}$ *puruṣa;* it has space for grass; the rim is larger than spokes by $\frac{8}{8}$ *puruṣa;* it is the dwelling (of Viṣṇu); it has the measure of $324\frac{1}{2}$ *aṅgulas* and a circle is made in the middle with its 20th part.

16.5. The bricks in the first layer of the chariot-wheel (fire-altar) are known to be 344.

16.6. In the second layer, there are 24 more bricks; five-cornered and three-cornered bricks are (used) in the joints of the rim and spokes.

16.7. The five layers of the chariot-wheel fire-altar are filled up with 1,768 bricks.

The *śulbasūtra* is concluded.

PART III

COMMENTARY

BAUDHĀYANA-ŚULBASŪTRA

Chapter 1

UNITS OF MEASUREMENTS, CONSTRUCTION OF SQUARES AND RECTANGLES, KNOWLEDGE OF SURD, THEOREM OF SQUARE ON THE DIAGONAL AND RELATED PROBLEMS.

In the first two chapters Baudhāyana has given a summary of geometrical knowledge and some results of mathematical interest required for the construction of sacrificial altars. How the knowledge was used in connection with the measuring of grounds and placing of different layers of bricks has been discussed in detail in subsequent chapters. This chapter deals specifically with the units of measurements of altars, methods of construction of squares and rectangles, application of surd numbers, and the theorem of square on the diagonal of a rectangle.

Units of Measurements

1.3. Baudhāyana's table of units of measurements runs as follows:

1 *aṅgula*	=	14 *aṇus*	=	34 *tilas;*
1 small *pada*	=	10 *aṅgulas;*		
1 *prādeśa*	=	12 *aṅgulas;*		
1 *pada*	=	15 *aṅgulas;*		
1 *iṣā*	=	188 *aṅgulas;*		
1 *akṣa*	=	104 *aṅgulas;*		
1 *yuga*	=	86 *aṅgulas;*		
1 *jānu*	=	32 *aṅgulas;*		
1 *śamyā*	=	36 *aṅgulas;*		
1 *bāhu*	=	36 *aṅgulas;*		
1 *prakrama*	=	2 *padas;*		
1 *aratni*	=	2 *prādeśas*	=	24 *aṅgulas;*
1 *puruṣa*	=	5 *aratnis*	=	120 *aṅgulas;*
1 *vyāma*	=	5 *aratnis;*		
1 *vyāyāma*	=	4 *aratnis;*		
1 *aṅgula*	=	$\frac{3}{4}$ inch[a] (approx.).		

Āpastamba (*Āśl.* 6.5, 15.4) has prescribed the same values of Baudhāyana for *iṣā, akṣa, yuga, puruṣa, vyāyāma, aratni* and *prādeśa.* These units of Āpastamba have been used by both Kātyāyana (*Kśl.* 2.1, 5.9) and Mānava (*Mśl.* 2.1, 4.4). The unit *pada* has been made equal to 12 *aṅgulas* by Kātyāyana (*Kśl.* 5.9). The term *vitasti* has been used in place of *prādeśa* by these two latter *śulbakāras* as well as by Kauṭilya in his *Arthaśāstra*[b], while its value remains the same. Mānava (*Mśl.* 4.2-4.4) has supplied some more units, e. g. 6 *tuṇḍa*=1 *bāla* of 3 years old calf; 3 *bālas*

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[a] Fleet, 233.

[b] Shamasastry (2), 117.

$=\frac{1}{2}$ mustard seed; 2 mustard seeds=1 *yava*[a]; 1 *aṅgula*=6 *yavas;* and 1 *prādeśa*=10 *vitastis.*

The units like *aṅgula, pada, prakrama, prādeśa, bāhu, aratni* carry a long tradition and have been used earlier in the *Saṃhitās* and Brāhmaṇic literature in the same sense as these have been used in the *Śulbasūtras.*[b]

Construction of Squares and Rectangles

1.4-1.5. *Square.* Baudhāyana has described here two methods of construction of squares.

First Method. Let XY be the given cord and U a mark at its middle (Fig. 1 (a)); EW, the *prāci* of the figure = XY; O the middle point of EW obtained corresponding to U of XY, where a pole is fixed.
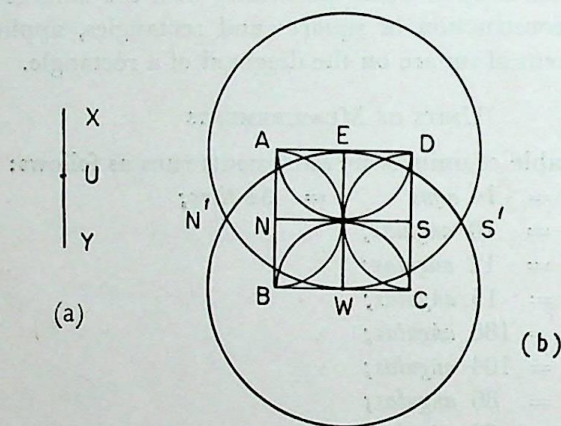
Fig.1. (a) Cord. (b) Square on a given length.

A circle with O as centre and OE as radius is drawn (Fig. 1(b)). Then EW is a diameter of the circle along east-west line. Two other circles with E and W as centres and EW as radius are separately drawn. The points of intersection of these two circles are denoted by N' and S' The line $N'S'$ fixes the second diameter NS of the circle whose centre is O. Again fastening the two ties once at E, W, N and S and drawing arcs, the points A, B, C, D are fixed. Then $ABCD$ gives the required square.

Second Method. Let XS, the given measure *(pramāṇa)* be a and XY, the increased cord, $2a$ (Fig. 2(a)). S is the mark at the middle of XY; then XS measures the length for *prāci*.

T is the *nyañcana* mark, so that $ST=\frac{1}{2}a-\frac{1}{4}a=\frac{1}{4}a$. U is another mark at the middle of SY.

XT, the diagonal *(akṣṇayā)* $= a+\frac{1}{4}a=\frac{5}{4}a$

TY, the breadth *(tiryaṅmāni)* $= 2a-\frac{5}{4}a=\frac{3}{4}a$

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a Shamasastry (1), 153, 55.

b Macdonell and Keith, II, 577, 584.

Clearly, $a^2 + (\frac{3}{4}a)^2 = (\frac{5}{4}a)^2$
In other words, $XY^2 + YT^2 = XT^2$.

$\therefore$ XYT is a right-angled triangle (Fig.2(b)).
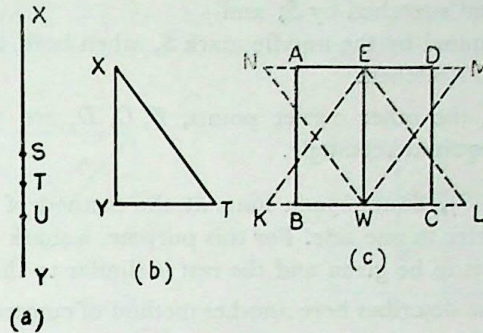
Fig. 2. (a) Cord. (b) Right-angled triangle.
(c) Square on a given length.

For the construction of any geometrical figure intended in the *śulbasūtra* XY is always stretched along east-west line, known as *pārśvamānī*, YT along north-south line, known as *tiryaṅmānī*, and XT along the diagonal known as *akṣṇayārajju*. Now it is easy to see how the right-angled triangle XYT has been used for the construction of the square.

The corners L and K (*śroṇi* points), M and N (*aṃsa* points) are fixed with the help of the point T of the triangle XYT [Fig.2(c)]. Then by using the half-cord UY, the points C, B, D and A are marked such that $WC = WB = ED = EA$. The figure $ABCD$ gives the required square.

1.6-1.7. *Rectangle and isosceles trapezium.* Baudhāyana's method of construction of rectangle with the help of a cord runs as follows:

Let XY be a piece of cord taken equal to the desired breadth of the rectangle [Fig. 3 (a)];

S, a mark at the middle of XY;
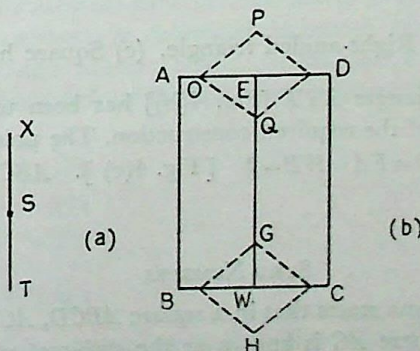
Fig. 3. (a) Cord. (b) Rectangle having desired length and breadth.

E, W, the *prāci* poles;

P and Q, G and H, poles at equal distances apart on both sides of each of the *prāci* poles.

O, the mark assigned by the middle mark S when ties at X and Y are fixed at P and Q and stretched by S; and

A, the point designated by the middle mark S, when both ties at X and Y are fixed at E and stretched.

In a similar way, the other corner points, B, C, D, are traced [Fig. 3(b)]. Hence $ABCD$ is the required rectangle.

In the rule (*Bśl.* 1.7), Baudhāyana hints at the method of construction of an isosceles trapezium shorter in one side. For this purpose, a mark on the cord according to desired length is to be given and the rest is similar to that of *Bśl.* 1.6.

1.8. *Square.* Baudhāyana describes here another method of construction of a square as follows:

Let XS be the cord of given measure a [Fig. 4(a)] ;

$XY = 1\frac{1}{2}a = \frac{3}{2}a$;

$SY = \frac{1}{2}\,a$;

T the *nyañcana* mark.

$\therefore XT = a + (\frac{1}{3}\cdot\frac{1}{2}\,a - \frac{1}{6}\cdot\frac{1}{2}\,a) = a + \frac{1}{12}\,a = \frac{13}{12}\,a$

and $TY = \frac{1}{2}\,a - \frac{1}{12}a = \frac{5}{12}\,a$

The relation $a^2 + (\frac{5}{12}\,a)^2 = (\frac{13}{12}\,a)^2$ holds,

i.e., $XY^2 + YT^2 = XT^2$.
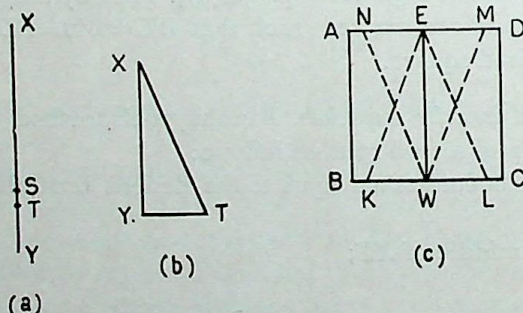
Fig. 4. (a) Cord. (b) Right-angled triangle. (c) Square having given side.

The right-angled triangle XYT [Fig. 4(b)] has been used to fix the corner points L, M, N, and K of the required construction. The points C, D, A and B are fixed such that $WC = ED = EA = WB = \frac{a}{2}$ [Fig. 4(c)]. $ABCD$ gives the required square.

Surd Numbers

1.9-1.11. Here Baudhāyana states that in a square $ABCD$, $AC^2 = 2\,AB^2$ [since $AB = BC$] or $AC = \sqrt{2}\,AB$, where AC is known as the *dvikaraṇi* of the measure AB. If $AB = a$, $AC = \sqrt{2}\,a$, where a is the measure. The result is sometimes considered by

scholars as a particular case of the more generalized rule given by Baudhāyana in *Bśl.* 1.10. But Baudhāyana gave no such hint. On the other hand, he has tried to establish a more generalized result on the basis of this statement. According to him, when the measure of the side of a square is a, its diagonal is $\sqrt{2}\,a$. Then again the measure of the diagonal of a rectangle having sides a and $\sqrt{2}\,a$, is $\sqrt{3}\,a$, for $a^2+(\sqrt{2}\,a)^2=(\sqrt{3}a)^2$; $\sqrt{3}a$ is known as the *tṛkaraṇi*. This result has been extended
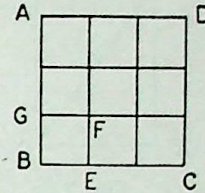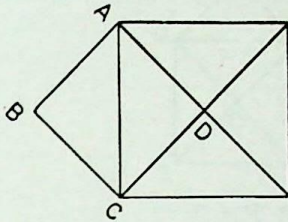
Fig. 5. Square on the diagonal. Fig. 6. Producer of *tṛkaraṇi* and *tṛtīyākaraṇī*.

to obtain the value of *tṛtīyākaraṇi* by both Āpastamba (*Āśl.* 2.2 and 2.3) and Kātyāyana (*Kśl.* 2.10 and 2.11). The commentators Kapardisvāmī, Sundararāja and Rāma have expressed in identical terms the value as well as meaning of this term. According to them, a square on the producer AB $(=\sqrt{3}a)$ when divided into nine equal parts by means of three parallel lines drawing from both sides, produces the square, $EBGF$ which is one-ninth of the square $ABCD$ (Fig. 6).

$$
\begin{aligned}
\text{Then } EB^2 &= \tfrac{1}{9}\ AB^2\\
\text{or } EB &= \tfrac{1}{3}\ AB\\
&= \tfrac{1}{3}\ \sqrt{3}\,a.\\
&= \frac{1}{\sqrt{3}}\ a.
\end{aligned}
$$

The producer EB is known as *tṛtīyākaraṇi* $= \dfrac{1}{\sqrt{3}}\,a$, where a is the side of the original square.

Theorem of Square on the Diagonal

1.12-1.13. The theorem states that in a rectangle $ABCD$, $AC^2=AB^2+BC^2$ (Fig. 7). This is a most general statement and is enunciated first by Baudhāyana. The proposition is stated almost in identical language by Āpastamba (*Āśl.* 1.4), Kātyāyana (*Kśl.* 2.7) and Mānava (*Mśl.* 10.10). Baudhāyana further says that the theorem is easily verified from the following relations:

$$
\begin{aligned}
3^2+4^2 &= 5^2\\
12^2+5^2 &= 13^2\\
15^2+8^2 &= 17^2\\
7^2+24^2 &= 25^2\\
12^2+35^2 &= 37^2\\
15^2+36^2 &= 39^2.
\end{aligned}
$$

No proof of this theorem is given by Baudhāyana and other *śulba* writers, since it is beyond their tradition to do so. Zeuthen, Cantor, Vogt, Cajori and Heath have

expressed the view that the general statement was possibly the result of an induction from a small number of cases of right-angled triangles having sides in rational numbers known to them. But this is not the actual case. Our discussions on rational rectangles and construction of geometrical figures amply justify that the general character of the theorem was rightly understood by the *śulbakāras*.
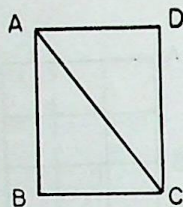
Fig. 7
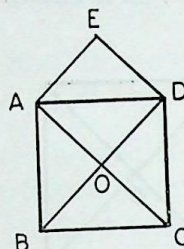
Fig. 8

A number of conjectures by Heath, Bürk, Müller, Thibaut, Datta and others as to the way the proof of the theorem could have been arrived at are available. A few of them are discussed in what follows.

(i) According to Heath[a], the problem of transformation of a square into a rectangle given by Baudhāyana in *Bśl.* 2.3. formed the basis of the proof. For, square *ABCD* drawn on the diagonal *AD* of the right-angled triangle *AGD* is equivalent to four equilateral triangles, while its sides *GD* and *AG* produce two each (Fig. 16). This has also established Bürk's hypothesis.[b]

(ii) The combination of two different squares as described by Baudhāyana in *Bśl.* 2.1 (Fig. 12) might have laid the foundation of the general statement of the theorem. This is according to Müller[c].

(iii) Thibaut[d] opined that the *śulbakāras* were observant of the fact that the square on *AD* is equivalent to four equal triangles, one of which is equal to half of the square on *OA* or *OD*, i.e. the squares on *OA* and *OD* together are equivalent to four equal triangles (Fig. 8). This pattern of arrangement of equilateral triangles are actually found in the first layer of construction with bricks in the *vakrapakṣaśyenacit* as described by Baudhāyana.

(iv) According to Datta,[e] the construction of the *paitṛki vedi* established the theorem of square on the diagonal. The altar is mentioned in the *Śatapatha Brāhmaṇa* (XIII.8.1.5) as a square with its corners pointed towards the cardinal directions. It is referred to by Baudhāyana (*Bśl.* 3.11) and also by Kātyāyana (*Kśl.*2.2), where the method of its construction in detail has appeared. The square *EGWH* obtained by joining the middle points of a square *ABCD* (of area 2 sq. *puruṣas*) is the *paitṛkī vedi* and is half (in area) of the original square (Fig. 29). The original square *ABCD* is a square on its east-west line *EW*. *EW* is again the diagonal of the newly formed square *EGWH*. This is undoubtedly a convincing proof (since $EW^2 = 2\,EG^2$).

[a] Heath, 352.
[b] Bürk, **55**, 556.
[c] Müller, 194-95.
[d] Datta (2), 111.
[e] Datta (2), 113-115.

(v) The knowledge of *dvikaraṇī*, *tṛkaraṇī*, discussed by Baudhāyana (*BŚl.* 1.9—1.11,) led in a way to the theorem of square on the diagonal.

(vi) Both Āpastamba (*ĀŚl.* 3.7) and Kātyāyana (*KŚl.* 3.7) gave an ingenious method for calculating the area of a square or rectangle, thereby establishing the theorem of square on the diagonal. According to this method, if there are p units in AB and q units in BC, then the rectangle $ABCD$ has pq square units, which can be obtained by drawing p number of parallel lines through p units of AB and q number of parallel lines through q points of BC (Fig. 9). This proves directly that $AC^2 = AB^2 + BC^2$.
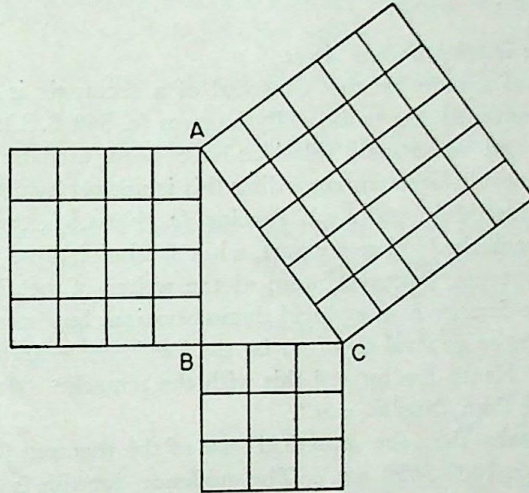
Fig. 9

(vii) Kātyāyana (*KŚl.* 2.4 and 2.5) has considered a rectangle of breadth 1 *pada* and length 3 *padas,* whose diagonal is a 10 fold producer. According to Datta[a], this justifies the statement of the theorem of square on the diagonal, as may be seen from Fig. 10. In the square $ABCD$, $DH = CG = CK = BF = AE = 1$ pada.
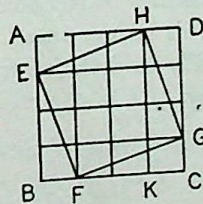
Fig. 10,
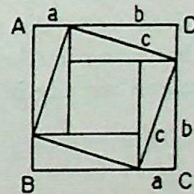
Fig. 11

Now *sq.* $ABCD$

$= sq$ on $BK + sq.$ on $DH + 4$ tr. AEH

$= AH^2 + AE^2 + 4$ tr. $AEH.$

Again *sq* $ABCD = EH^2 + 4$ tr. AEH

$\therefore AH^2 + AE^2 = EH^2$

[a] Datta (2), 115-116.

(viii) Datta[a] has given another proof of this theorem. Four rectangles each equal to a given rectangle having breadth a, length b and the diagonal c are so constructed that the diagonal of each rectangle forms the side of a square (Fig. 11). Then

$$c^2 = (a + b)^2 - 4\left(\tfrac{1}{2}ab\right)$$

or, $c^2 = a^2 + b^2$.

Although such specific constructions and arguments are not supplied as proofs by the *śulbakāras*, ample evidence is left by them in their details of constructions to believe that the proofs of the theorem of square on the diagonal of a rectangle were known to them.

Pythagorean Theorem in other Culture Areas.

The theorem of square on the diagonal of a rectangle is usually known as Pythagorean theorem after the name of Pythagoras (c. 540 B.C.). In fact, the relation $3^2 + 4^2 = 5^2$ and some such relations have been used by Pythagoras, but evidence of any general statement regarding this is not yet available. Actual proof was first given by Euclid (*c.* 300 B.C.). Proclus (*c.* 460 A.D.), the commentator of Euclid's *Elements*[b] remarked: "For my part, while I admire those who first observed the truth of the theorem, I marvel more at the writer of the *Elements,* not only because he made it first by a most lucid demonstration, but because he compelled assent to the still more general theorem by the irrefragable arguments of science in the sixth book." Heath has quoted this with the remark:[c] "It is difficult for us to be more positive than Proclus was".

It is fairly certain that the practical use of the theorem was current in old Babylonian times (*c.* 1800-1600 B.C.). The evidence for this is found in certain Babylonian cuneiform tablets. No general theorem was found to have been mentioned. It has been conclusively proved by Neugebauer that Pythagoras derived his "Number theorem of Universe" as well as the so-called Pythagorean theorem from cuneiform tablets.[d] The Chinese knew of a similar relation which appeared in *Chou Pei* (4th century B.C.), but it really became well known from the time of its first commentator Chao Chun Chhing[e] (3rd century A.D.). A proof of the theorem was given by Bhāskara II[f] (1150 A.D.). According to Needham, Bhāskara II's treatment was derived from the *Chou Pei.*[g] This is not true, for the proof of Bhāskara II and that given in *Chou Pei* can readily be deduced from a number of constructions described already in the *Śulbasūtras*.

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[a] Datta (2), 117

[b] *Elements,* Book I, prop. 47.

[c] Heath (3), 96.

[d] Neugebauer, 28-42.

[e] Needham, 95.

[f] *Bījagaṇita*, 70.

[g] Needham, 19.

CHAPTER 2

TRANSFORMATION OF GEOMETRICAL FIGURES

This chapter deals with the method of combination or difference of two separate squares into a square and the transformation of a square into a rectangle, an isosceles trapezium or a circle and vice versa.

CONSTRUCTION OF A SQUARE BEING SUM OF, DIFFERENCE BETWEEN, TWO SQUARES

2.1-2.2. These two rules of Baudhāyana give the methods of construction of a square as the sum and difference of two different squares.

Here three technical terms, *hrasiyasaḥ, varṣiyasaḥ* and *vṛddhram* are used. According to Kapardisvāmī,[a] *hrasiyasa* means the side of the smaller square, *varṣiyasa* the side of the larger square and *vṛddhram* the rectangular portion *(dirghacaturaśram)*.

Method of combination (samāsa).

For the combination of a smaller square *EBGF* with another square *ABCD*, this rule of Baudhāyana suggests that the rectangular portion *ABGH* is cut off by the side of the smaller square whose side is equal to *BG*. Then *AG* of this cut-off portion will be the side of the combined square (Fig. 12).
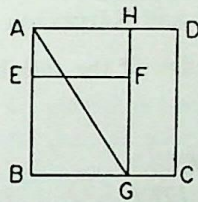
Fig. 12.
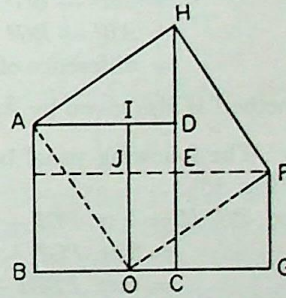
Fig. 13.

Evidently,

$$AG^2 = AB^2 + BG^2 = \text{sum of two squares.}$$

The same method is also given by Āpastamba (*Āśl.* 2.4) and Kātyāyana (*Kśl.* 2.13).

PROOF : Datta[b] has suggested the following proof of this proposition (Fig. 13).

$$\begin{aligned} \text{sq. } ABCD + \text{sq. } ECGF \\ &= \text{tr. } ABO + \text{tr. } AOI + \text{tr. } OFG + \text{tr. } OFJ + \text{sq. } IJED \\ &= \text{tr. } ADH + \text{tr. } AOI + \text{tr. } HEF + \text{tr. } OFJ + \text{sq. } IJED \\ &= \text{sq. } AOFH \end{aligned}$$

or, $AB^2 + CG^2 = AO^2$

[a] *Āśl.* Mysore 73, 39.

[b] Datta (2), 77.

Method of difference (nirhāra).

To construct a square equal to the difference between a smaller square *EBGF* and other square *ABCD*, the rule *Bśl.* 2.2 suggests that the rectangular portion *ABGH* is cut off by the side *BG* of the smaller square. Then the side *GH* of the cut off portion is allowed to fall on *AB*, and *P* is the point where it falls. Here $GH = GP$. Then *BP* is the side of a square which is equal to the difference of the squares *ABCD* and *EBGF* (Fig. 14).
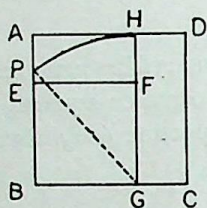
Fig. 14.
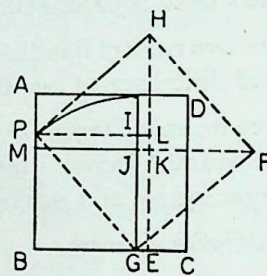
Fig. 15.

Evidently,

$$\begin{aligned} BP^2 &= GP^2 - BG^2 \\ &= GH^2 - BG^2 \\ &= AB^2 - BG^2 \\ &= \text{difference of two squares } ABCD \text{ and } EBGF. \end{aligned}$$

The method is also given by Āpastamba (*Āśl.* 2.5) and Kātyāyana (*Kśl.* 3.1).

PROOF : The following proof based on the knowledge of the *śulbakāras* is due to Datta[a] (Fig. 15).

$$\begin{aligned} \text{Now, sq. } PGFH &= 4 \text{ tr. } PGI + \text{sq. } IJKL \\ &= 2 \text{ tr. } PGI + 2 \text{ tr. } PGI + \text{sq. } IJKL \\ &= \text{rect. } PBGI + \text{rect. } PBGI + \text{sq. } IJKL \\ &= (\text{rect. } PBGI + \text{sq. } IJKL) + \text{rect. } PBGI \\ &= (\text{rect. } PBGI + \text{sq. } IJKL) + \text{sq. } MBGJ + \text{rect. } PMJI \\ &= (\text{rect. } PBGI + \text{sq. } IJKL + \text{rect. } PMJI) + \text{sq. } MBGJ \\ &= (\text{rect. } PBGI + \text{sq. } IJKL + \text{rect. } JGEK) + \text{sq. } MBGJ \\ &= \text{sq. } PBEL + \text{sq. } MBGJ \\ \text{or, sq } PBEL &= \text{sq. } PGFH - \text{sq. } MBGJ \\ \therefore BP^2 &= PG^2 - BG^2 \\ \text{or } BP^2 &= AB^2 - BG^2 \end{aligned}$$

TRANSFORMATION OF A SQUARE INTO A RECTANGLE

2.3-2.4. Baudhāyana has given two methods for transformation of a square into a rectangle.

According to the first method, a square is transformed into a rectangle, such that the diagonal of the square equals the longer side of the rectangle. The method is also given by Kātyāyana (*Kśl.* 3.4).

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[a] Datta (2), 79.

The square $ABCD$ is divided by its diagonal AC (Fig. 16). The portion ADC is again divided into two equal halves by GD and each is transferred to occupy the position AEB and BFC. Then $AEFC$ is the required rectangle. For,

$$\begin{aligned} \text{sq. } ABCD &= \text{tr. } ABC + \text{tr. } AGD + \text{tr. } GCD \\ &= \text{tr. } ABC + \text{tr. } AEB + \text{tr. } BFC \\ &= \text{rect. } AEFC. \end{aligned}$$

The method is limited in scope, for it only turns a square into a rectangle, the longer side of which is equal to the diagonal of the square.

The second method concerns the transformation of a square into a rectangle of which one side is given. The same rule is also given by Āpastamba (*Āśl.* 3.1). Both Baudhāyana and Āpastamba gave no clear exposition of the second half of this *sūtra*. To substantiate this rule, Thibaut,[a] considered as an instance a square of side 5 units and changed it into a rectangle of 3 units by $8\frac{1}{3}$ units. Likewise, Bürk[b] transformed a square of side 6 units into a rectangle of 4 units by 9 units as follows.
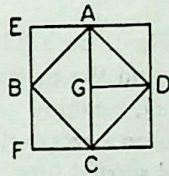
Fig. 16.
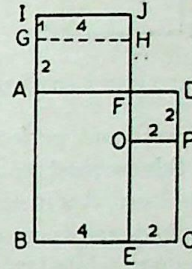
Fig. 17.

The sq. $ABCD$ is broken into a rect. $ABEF$ making its side BE ($= 4$ units) equal to the desired shorter side of the rectangle, and rectangle $OECP$ (where $EC = 2$ units), together with a square $FOPD$. The rectangle $OECP$ is transferred to the other side, and $GAFH$ is its new position. Next the smaller square $FOPD$ (2 units $\times$ 2 units) is changed into a rectangle (of 1 unit by 4 units) and $IGHJ$ becomes its new position (Fig. 17). Hence BI $(6 + 2 + 1 = 9$ units) is the length of the new rectangle. Similarly, if we change a square of 7 units into a rectangle of 5 units by $\frac{49}{5}$ $(= 7 + 2 + \frac{4}{5})$ units, we have to construct a rectangle of $\frac{4}{5}$ unit by 5 units from a square of 2 units by 2 units. This is actually no solution to the problem since the transformation of square $FOPD$ to a rectangle $IGHJ$ is again a problem of fundamental nature.

The commentators Dvārakānātha Yajvā and Sundararāja have described a general method as follows : *yāvadiccham pārśvamānyau prācyau vardhayitvā uttarapūrvām karṇarajjumāyacchet sā dirgha caturaśramadhyasthāyām samacaturaśra tiryaṅmānyām yatra nipatati tata uttaram hitvā dakṣiṇāmsam tiryaṅmānīm kuryāt taddirghacaturaśram bhavati|* This means: Having increased upto the desired length the two sides *(pārśvamāni)*

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[a] Thibaut (1), 246.

[b] Bürk, **56,** 334.

[c] Thibaut (1), 247.

towards east, the diagonal-cord is stretched towards north-east corner. The (diagonal) line cuts the breadth *(tiryaṅmānī)* of the square lying inside the rectangle; the northern portion is cut off (by drawing a line through this point parallel to *prācī*); the southern side becomes the breadth *(tiryaṅmānī)* of the (desired) rectangle.

In Fig. 18, the sides BA and CD of the square $ABCD$ are increased to E and F respectively, so that each of the sides BE and CF becomes equal to the given length PQ. The diagonal cord CE cuts the side AD at O. Then the northern portion $EBHG$ is cut off by drawing a line HG passing through O parallel to the *prācī* line BA. Now $GHCF$ is the required rectangle.

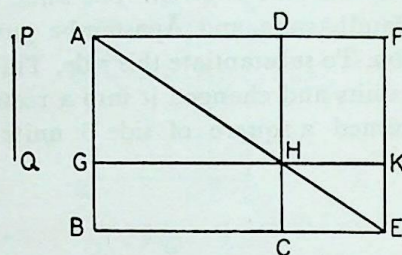
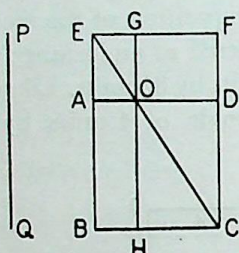



Fig. 18. Square into a rectangle. Fig. 19. Square into a rectangle of given side.

This is a general and perfectly satisfactory method. Both Thibaut and Bürk did not consider this method as that of Baudhāyana on the ground that Baudhāyana himself mentioned this method as *anyaśca prakāraḥ,* meaning 'another method'. Baudhāyana's method was to cut off from a given square a rectangle of side smaller than that of the square while Dvārakānātha's method started from the construction of a rectangle of side greater than that of the square. From our discussion it is clear that in the methods suggested by both Baudhāyana and Dvārakānātha, the final result of constructing a rectangle equivalent to a square is the same but their methods of attaining it are different. For this difference, Sundararāja gave the same line of argument as that of Dvārakānātha in transforming a square into a rectangle with the remark, *ayamatra prakāraḥ*[a] meaning, 'this is the method taught here'. To keep a symmetry with the original *sūtra* of Baudhāyana, Datta[b] put the method of Dvārakānātha in the following form.

From the square $ABCD$, the portion $AGHD$ is cut off, such that $AG = DH = PQ$, the side of the required rectangle. The diagonal AH is produced to meet BC (produced) at E. The rectangle $ABEF$ is completed. Then $AGKF$ is the equivalent rectangle (Fig. 19).

For, tr. $ABE =$ tr. AFE, tr. $AGH =$ tr. ADH and tr. $HCE =$ tr. HKE. Hence rectangle $GC =$ rectangle DK.

$$\begin{aligned}\text{Now sq. } ABCD &= \text{rect. } AH + \text{rect. } GC\\ &= \text{rect. } AH + \text{rect } DK\\ &= \text{rect. } AK.\end{aligned}$$

[a] *Āsl.* Mysore 49.

[b] *Datta* (2), 90.

Transformation of a Rectangle into a Square

2.5. This is a most general method of transforming a rectangle into a square given by Baudhāyana. The same method is also taught by Āpastamba (*ĀŚl.* 2.7) and Kātyāyana (*KŚl.* 3.2). Baudhāyana's method runs as follows.

Let $ABCD$ be the given rectangle (Fig. 20). The portion $ABFE$ is cut off such that $AE = AB =$ the breadth of the rectangle. The remaining portion $EFCD$ is cut off into two equal halves. One half $GHCD$ is placed on the other side and its new position becomes $BKLF$. A small square $FLMH$ is fitted at the corner.

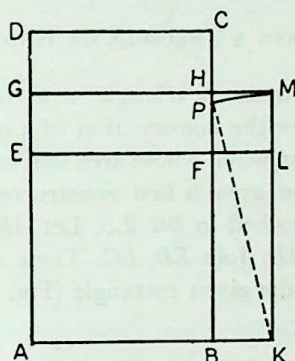



Fig. 20. A rectangle into a square.

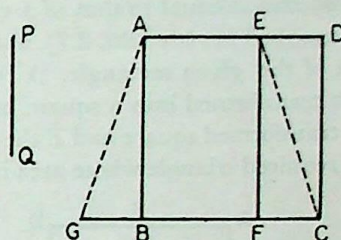



Fig. 21. A square into an isosceles trapezium.

Now, rect. $ABCD =$ sq. $AKMG$ — sq. $FLMH$, which shows that the rectangle $ABCD$ is expressed as the difference of two squares. Since the method of *nirhāra* has already been taught before by Baudhāyana (*BŚl.* 2.2), a square equal to the difference of the two squares mentioned above is found by allowing the side KM to fall at P over BH. Then the square on BP will be equal to the difference of two squares, which is equal to the area of the given rectangle.

For, $BP^2 = PK^2 - BK^2$
$= MK^2 - FL^2$
$=$ sq. $ABFE +$ rect. $EFHG +$ rect. $FBKL$
$=$ sq. $ABFE +$ rect. $EFHG +$ rect. $DGHC$
$=$ rect. $ABCD$.

In the case of a rectangle of very great length, Kātyāyana's (*KŚl.* 3.3) advice is to cut it again and again by its breadth, combine the pieces by the *samāsa* method (*BŚl.* 2.1) and finally to achieve the result by applying the *nirhāra* method (*BŚl.* 2.2). This is clearly no improvement upon the method given by Baudhāyana.

Transformation of a Square or Rectangle into an Isosceles Trapezium

2.6. By this method a square as well as a rectangle are changed into a trapezium of given side (smaller than the side of the square).

The square $ABCD$ is required to be transformed into an isosceles trapezium $AGCE$, whose shorter side AE is equal to the given length PQ (Fig. 21). The

rectangular portion $EFCD$ is divided into two equal halves and the half ECD is shifted to its other side, such the AGB is its new position. Hence $AGCE$ is the required isosceles trapezium.

$$\begin{aligned} \text{For, sq. } ABCD &= \text{rect. } ABFE + \text{tr. } EFC + \text{tr. } ECD \\ &= \text{rect. } ABFE + \text{tr. } EFC + \text{tr. } AGB \\ &= \text{trap. } AGCE \end{aligned}$$

This method of transformation was known earlier in the *Śatapatha Brāhmaṇa* (*Śat. Br.* 10.2.1.4).

Transformation of a Rectangle or Square into a Triangle or Rhombus

2.7-2.8. Baudhāyana has given a method of constructing a triangle or a rhombus whose area is equal to that of a given rectangle. For the construction of a triangle as described in *sūtra* (*Bśl.* 2.7), a square is to be constructed whose area will be twice that of the given rectangle. A rectangle twice the area is first constructed and then transformed into a square by the method described in *Bśl.* 2.5. Let $ABCD$ be the transformed square and E the middle point of AD. Join EB, EC. Then EBC is the required triangle whose area is equal to that of the given rectangle (Fig. 22).

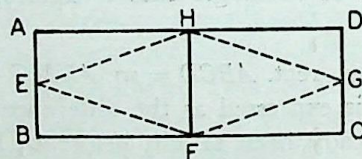
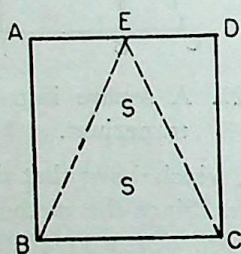



Fig. 22. A rectangle into a triangle. Fig. 23. A rectangle into a rhombus.

For, tr. $EBC = \frac{1}{2}$ sq. $ABCD$ = given rectangle.

For the construction of a rhombus as in *sūtra* (*Bśl.* 2.8), let the rectangle $ABCD$ be so constructed that its area is double that of the given rectangle. Let E, F, G, H be the middle points of AB, BC, CD and DA respectively. Join EF, FG, GH and HE to produce the required rhombus $EFGH$ (Fig. 23).

$$\begin{aligned} &\text{For, rhombus } EFHG \\ &\quad = \text{tr. } EFH + \text{tr. } GFH \\ &\quad = \tfrac{1}{2}\,(\text{rect. } ABFH + \text{rect. } CDHF) \\ &\quad = \tfrac{1}{2}\,\text{rect. } ABCD \end{aligned}$$

This is given by both Āpastamba (*Āśl.* 12.8) and Kātyāyana (*Kśl.* 4.4).

Transformation of a Square into a Circle.

2.9. The following method of transforming a square into a circle is given by Baudhāyana. The same method has also been taught by Āpastamba (*Āśl.* 3.2), Kātyāyana (*Kśl.* 3.11) and Mānava (*Mśl.* 1.8).

Let $ABCD$ be the given square and O its centre. The half diagonal OA is drawn over the east-west line OE, such that $OA = OE$. Then a circle with radius OF equal to OG plus $\frac{1}{3}$ of GE i.e. GF, is drawn to give the required circle (Fig. 24).

$$\text{Here, radius} = OF = OG + GF$$
$$= OG + \tfrac{1}{3}\,GE$$
$$= OG + \tfrac{1}{3}\,(OA - OG).$$

Fig. 24.

Let $2a$ be the side of the square $ABCD$.

$$OF = a + \tfrac{1}{3}\,(a\sqrt{2} - a)$$

or $r = a\,[1 + \tfrac{1}{3}\,(\sqrt{2} - 1)]$, where $OF = r$

or $r = \dfrac{a}{3}(2 + \sqrt{2})$

As per *Bśl* 2.12 (*vide infra*), $\sqrt{2}$ is given by,

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34}$$
$$= \frac{577}{408} = 1.4142156\ldots$$

Baudhāyana's more refined value of π is given by (*Bśl.* 4.15),

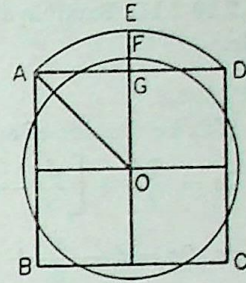
$$\pi = 4\left(1 - \frac{1}{8} + \frac{1}{8.29} - \frac{1}{8.29.6} + \frac{1}{8.29.6.8}\right)$$
$$= 3.0885.$$

Using the above value of $\sqrt{2}$ and π, the area of the transformed circle $= \pi r^2 = 3.9989a^2$, which is in close agreement with the area of the given square, $4a^2$.

If we take $\pi = 3$ (*Bśl.* 4.15), area of the circle becomes $3.885a^2$, which falls far short of the area of the given square. Āpastamba made an additional remark on the method of circling a square as *sānityā maṇḍalaṃ yāvaddhīyate tāvadāgantu*, which makes also the interpretation equally difficult as to whether the method is exact or inexact one. The commentator Kapardisvāmī has broken up *sānityā* as *sā* and *anityā* concluding that the method is an inexact one. The passage has been interpreted by Karavindasvāmī as follows: 'The circle is exactly as large as the square, for as much the circle falls short, so much comes in.'[a] Thibaut, Bürk and Datta have referred to the same difficulty as to the real sense in which these words were used by Āpastamba.[b]

However, Dvārakānātha Yajvā[c], commentator of *Baudhāyana śulba* has proposed the following correction to the formula of Baudhāyana, which gives better result:

$$r = \left[a + \frac{a}{3}\left(\sqrt{2} - 1\right)\right]\left(1 - \frac{1}{118}\right)$$

[a] *Āśl.* Mysore, 50.
[b] Datta (2), 142-43.
[c] Thibaut (2), **10**, 21.

The problem of quadrature has also been discussed by Drenckhahn,[a] Chakrabarty,[b] and Gurjar.[c]

Transformation of a Circle to a Square

2.10-2.11. Baudhāyana describes two methods of finding quadrature of a circle.

First Method.

If $2a$ be the side of a square and d the diameter of the circle, then

$$2a = \frac{7d}{8} + \left[\frac{d}{8} - \left\{\frac{28d}{8.29} + \left(\frac{d}{8.29.6} - \frac{d}{8.29.6.8}\right)\right\}\right]$$

$$\text{or, } 2a = d - \frac{d}{8} + \frac{d}{8.29} - \frac{d}{8.29}\left(\frac{1}{6} - \frac{1}{6.8}\right)$$

Second Method.

$$2a = d - \frac{2}{15}d$$

This result is also given by both Āpastamba (*Āśl.* 3.3) and Kātyāyana (*Kśl.* 3.12)

Rationale.

(A) The rationale of the result obtained from the first method is given by Thibaut, Cantor and Müller as follows :

(i) Thibaut[d] has suggested that the result was possibly obtained from the previous result of circling a square, $r = \frac{a}{3}(2 + \sqrt{2})$ by inversion.

$$\text{For, } 2a = \frac{3}{2+\sqrt{2}}d$$

$$= \frac{1224}{1393}d \qquad \because \sqrt{2} = \frac{577}{408}$$

$$= d\left(\frac{7}{8} + \frac{1}{8.29} - \frac{1}{8.29.6} + \frac{1}{8.29.6.8}\right)$$

since, 1) 1/8th of 1393 = $174\frac{1}{8}$.

2) 7/8th of 1393 = $1218\frac{7}{8}$ (less by $5\frac{1}{8}$ from 1224)

3) $\frac{1}{8.29}$ th of 1393 = 6 (approx)

4) $\frac{1}{8.29.6}$ th of 1393 = 1

5) $\frac{1}{8.29.6.8}$ of 1393 = $\frac{1}{8}$

(3–5: i.e. $6 - 1 + \frac{1}{8} = 5\frac{1}{8}$ surplus by $5\frac{1}{8}$ from 1224)

More or less the same method is given by Cantor.[e]

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[a] Drenckhahn, 1-13.

[b] Chakrabarty (2), 23-28.

[c] Gurjar (2), 11-16.

[d] Thibaut (1), 254.

[e] Datta (2), 145.

(ii) Müller's derivation[a] is as follows :

$$2a = \frac{3}{2+\sqrt{2}}\,d = \frac{3\sqrt{2}}{2\sqrt{2}+2}\,d = \tfrac{3}{2}\cdot\frac{\sqrt{2}}{1+\sqrt{2}}\,d$$

$$= \left(\frac{3}{2}\cdot\frac{17-\frac{1}{34}}{29-\frac{1}{34}}\right)d = \left(\frac{51-\frac{3}{34}}{58-\frac{2}{34}}\right)d \quad \because \sqrt{2} = \frac{17}{12} - \frac{1}{12.34}$$

$$= \left(1 - \frac{7+\frac{1}{34}}{58-\frac{2}{34}}\right)d$$

$$= d - \frac{1}{8}\cdot\left(\frac{56+\frac{8}{34}}{58-\frac{2}{34}}\right)d = d - \frac{1}{8}\left[1 - \frac{2-\frac{10}{34}}{58-\frac{2}{34}}\right]d$$

$$= d - \frac{1}{8}\left[1 - \frac{1}{29}\left(1 - \frac{\frac{10}{34}-\frac{2}{34.29}}{2-\frac{2}{34.29}}\right)\right]d$$

$$= d - \frac{1}{8}\,d\left[1 - \frac{1}{29}\left\{1 - \frac{1}{6}\left(1 - \frac{4+\frac{5}{29}}{34-\frac{1}{29}}\right)\right\}\right]$$

$$= d - \frac{1}{8}\,d + \frac{1}{8.29}\,d\left[1 - \frac{1}{6}\left\{1 - \frac{1}{8}\left(1 - \frac{2-\frac{41}{29}}{34-\frac{1}{29}}\right)\right\}\right]$$

Thus,

$$2a = d - \frac{d}{8} + \frac{d}{8.29} - \frac{d}{8.29}\left(\frac{1}{6} - \frac{1}{6.8}\right) - \frac{d}{8.29.6.8}\cdot\frac{2-\frac{41}{29}}{34-\frac{1}{29}}$$

The last term is neglected, it being very small.

However, Dvārakānātha[b] has suggested a more correct result of the above formula as follows :

$$2a = \left[d - \frac{d}{8} + \frac{d}{8.29} + \frac{d}{8.29}\left(\frac{1}{6} - \frac{1}{6.8}\right)\right] \times \left(1 + \frac{1}{2}\cdot\frac{3}{133}\right)$$

(B) The rationale of the second method may be obtained as follows :

The average of two squares, one circumscribed and the other inscribed, determines the approximate area of the circle.

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[a] Müller, 201.

[b] Thibaut (2), **10**, 21.

$\therefore$ Area of the circle $= \dfrac{4r^2 + 2r^2}{2} = 3r^2$

Since the square is taken to be equal in area to the circle,

$4a^2 = 3r^2$

or $a = \dfrac{\sqrt{3}}{2} r$

The value of $\sqrt{3}$ may be obtained by the method of successive approximation as follows:

(i) $\sqrt{A} = \sqrt{a^2 + c} = a + \dfrac{c}{2a + 1}$,

where $2a + 1$ is the difference between the squares of c and the next positive integer. Therefore,

$\sqrt{3} = \sqrt{1^2 + 2} = 1 + \frac{2}{3} = \frac{5}{3}$

(ii) For finding the next approximation e, $\sqrt{A}$ is written as

$\sqrt{A} = a + \dfrac{e}{2a + 1} + e$

Then squaring both sides and cancelling the value of e^2, since it is very small, the value of e is obtained.

Here $\sqrt{3} = \frac{5}{3} + e$

Squaring and cancelling the value of e^2 we get

$\dfrac{10}{3} e + \dfrac{25}{9} = 3$

or $e = \dfrac{1}{15}$

then $\sqrt{3} = 1 + \dfrac{2}{3} + \dfrac{1}{15} = \dfrac{26}{15}$

Obviously,

$$a = \frac{1}{2} \cdot \sqrt{3}\, r = \frac{1}{2} \cdot \frac{26}{15} r = \frac{13}{15} r$$

$$= r - \frac{2}{15} r \; [\, r = \text{radius} \,]$$

or $2\, a = d - \dfrac{2d}{15}$ [$d = 2r =$ diameter]

The value of $\sqrt{2}$

2.12 : The value of $\sqrt{2}$ given by Baudhāyana is

$$\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34} \text{ (approx.)}$$

The same *sūtra* is also given by Āpastamba (*Āśl.* 1.6) and Kātyāyana (*Kśl.* 2.9).

In decimal fraction, the above value of $\sqrt{2} = 1.4142156$. According to modern calculation, $\sqrt{2} = 1.4142135$. Thus it is clear that the ancient Indians attained a remarkable degree of accuracy in calculating an approximate value of $\sqrt{2}$. The *śulbakāras* gave methods, for constructing a square equal to the sum of two equal squares, but gave no method of calculating the value of its diagonal.

Thibaut, Rodet, Datta, and others gave possible methods of solution for arriving at the value as follows:—

(i) *Thibaut's proof.*[a]

Now, $17^2 = 2.12^2 - 1$. Thibaut argued, by how much the side 17 must be diminished in order that the square on it may be 2.12^2 exactly. Since $2 \times 17 \times \frac{1}{34} = 1$, he observed, two strips each of $\frac{1}{34}$ (approximately) are to be cut off from a square with 17 as side to obtain the square 2.12^2 (i.e. $12^2 + 12^2$).

$$\text{Hence, } \left(17 - \frac{1}{34}\right)^2 = 2.12^2$$

$$\text{or, } \frac{17 - \frac{1}{34}}{12} = \sqrt{2}$$

$$\text{Again, } 17 - \frac{1}{34} = 12 + 4 + 1 - \frac{1}{34}$$

$$\text{or, } 17 - \frac{1}{34} = 12\left(1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34}\right)$$

$$\text{or, } \frac{17 - \frac{1}{34}}{12} = 1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34}$$

$$\text{or, } \sqrt{2} = 1 + \frac{1}{3} + \frac{1}{2.4} - \frac{1}{3.4.34}$$

In Baudhāyana's selection of units of 12 *aṅgulas* (= 1 *pada*) and 34 *tilas* (= 1 *aṅgula*) Thibaut found justification for the choice of the arbitrary relation $17^2 = 2.12^2$ (approx.) leading to the origin of the formula of $\sqrt{2}$, as given in the text.

(ii) *Rodet's approximation.*[b]

According to Rodet, the approximation adopted by *śulbakāras* may be obtained by successive approximation.

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[a] Thibaut (1) 239-41

[b] Rodet, 162-165

$$\sqrt{a^2+r} = a + \frac{r}{2a+1} + \frac{\frac{r}{2a+1}\left(1-\frac{r}{2a+1}\right)}{2\left(1+\frac{r}{2a+1}\right)} + e$$

where e is a fourth term approximation.

Rodet might have obtained the result as follows :

$\sqrt{a^2+r} = a + \frac{r}{2a+1}$ [two term approximation] where $2a + 1$ is the difference of the squares of a and the next positive integer $a + 1$.

For third term approximation, assume

$$\sqrt{a^2+r} = a + \frac{r}{2a+1} + e_1$$

$$= \frac{2a+r+1}{2a+1} + e_1$$

Squaring and neglecting e_1^2, we get

$$\frac{2\,(2a+r+1)}{2a+1}\,e_1 = a^2 + r - \left(\frac{2a+r+1}{2a+1}\right)^2$$

$$= \frac{r\,(2a+1-r)}{(2a+1)^2}$$

$$\therefore e_1 = \frac{r\,(2a+1-r)}{2\,(2a+1)\,(2a+1+r)}$$

$$= \frac{\frac{r}{2a+1}\left(1-\frac{r}{2a+1}\right)}{2\left(1+\frac{r}{2a+1}\right)}$$

Likewise, the fourth term approximation is obtained.

Obviously, following above, we write,

$$\sqrt{2} = \sqrt{1^2+1} = 1 + \frac{1}{3}$$

Let $\sqrt{2} = 1 + \frac{1}{3} + e = \frac{4}{3} + e$

Squaring both sides and cancelling e^2 from both sides, we get

$$\frac{8}{3}\,e = 2 - \frac{16}{9} = \frac{2}{9}$$

$$\therefore e = \frac{2}{9} \times \frac{3}{8} = \frac{1}{12} = \frac{1}{3.4}$$

$$\therefore \sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4}$$

Let $\sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4} + e$

$$= \frac{17}{12} + e$$

Squaring both sides and cancelling e^2 from both sides,

$$\frac{17}{6}\,e = 2 - \left(\frac{17}{12}\right)^2 = -\,\frac{1}{144}$$

$$\therefore e = -\,\frac{1}{144} \times \frac{6}{17} = \frac{1}{12.34}$$

$$= -\,\frac{1}{3.4.34}$$

$$\therefore \sqrt{2} = 1 + \frac{1}{3} + \frac{1}{3.4} - \frac{1}{3.4.34} \text{ (approx.)}$$

The methods described later by Gurjar[a] and Gupta[b] are the same and no improvement over Rodet's method.

(iii) *Datta's proof.*[c]

Datta's proof is an improvement over that of Thibaut and maintains the method of construction followed in the *śulba.*

The method consists in constructing a square with area equal to the sum of the areas of the two other squares having sides of one unit in length (Fig. 25).
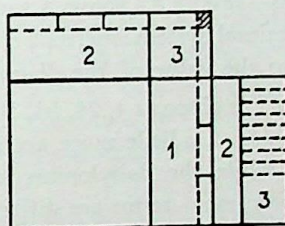
Fig. 25.

For this one of the two squares having side of unit length is divided into three equal parts by lines drawn parallel to one of its sides. Each of these parts forms a rectangular piece of one unit in length and one-third unit in width. Two of these rectangular parts are then joined length-wise to the two adjacent sides of the other unit square. This leaves a square hole at one of the corners of the enlarged unit square. This square hole will have a side of one-third unit in length. The remaining rectangular piece of the divided unit square is again subdivided into three equal parts each forming a square of side one-third unit in length. One of the squares is fitted into the square hole mentioned above. Each of the remaining two squares is again subdivided into four equal rectangular pieces having length of $\frac{1}{3}$ unit and width of $\frac{1}{3.4}$ unit. Eight of these small rectangular pieces are placed length-wise side by side on the two adjacent sides of

[a] Gurjar (1), 6-10.
[b] Gupta, 77-79.
[c] Datta (2), 192-94.

the enlarged square with four on each side. This again leaves a square hole at the corner having a side of length $\frac{1}{3.4}$ unit. Now two equal strips have to be deducted from the two adjacent sides of the enlarged square under construction; the width of each of the strips is therefore given by

$$\frac{\left(\frac{1}{3.4}\right)^2}{2\times\left(1+\frac{1}{3}+\frac{1}{3.4}\right)} = \frac{1}{3.4.34}$$

Hence $\sqrt{2}$, the side of the desired square is given approximately by

$$1+\frac{1}{3}+\frac{1}{3.4}-\frac{1}{3.4.34}.$$

Value of $\sqrt{2}$ in other culture areas.

A small cuneiform tablet (Yale Babylonian collection No. 7289) of the old Babylonian times (c. 1800—1600 B.C.) shows a square with its two diagonals, with three numbers in sexagesimal system inscribed on it. These three numbers are interpreted by Neugebauer[a] as the value of the diagonal, a side and the value of $\sqrt{2}$ (since $d = \sqrt{2}\, a$). Here $\sqrt{2}$ is given as 1, 24, 51, 10, which in terms of decimals comes out to be 1.41421,291......., a little more accurate than the Indian value. The Indian value is smaller while the Babylonian value larger than the actual value. Moreover, their first fractional terms are different. The suggestion that the Indian value might have been obtained from a Babylonian source is groundless. As regards Greek[b] sources, many approximations to the value of $\sqrt{2}$ are known, but not a value of this order of accuracy.

Irrationality of $\sqrt{2}$.

Baudhāyana, Āpastamba and Kātyāyana gave the value of $\sqrt{2}$, as mentioned above, with an additional term *viśeṣa* (approximate). Many scholars expressed doubt whether, by the term *viśeṣa*, the *śulbakāras* recognized the irrationality of $\sqrt{2}$. According to Karavindasvāmī,[c] a commentator on the *Āpastambaśulbasūtra,* the root *śiṣ* when prefixed by *vi* denotes in all cases a 'correction in excess'. Datta[d] has discussed the matter in detail, and the commentator can be relied upon in this interpretation. Looking into the ancient literature of India, we find in the early canonical works of the Jainas many instances of the employment of the term *viśeṣa* in the same connection as we find in the *śulba.* A few instances are given here.

[a] Neugebauer, 34, vide also *Plate 6a.*

[b] Heath (2), 155.

[c] *Āśl.*, Mysore 73.

[d] Datta (2), 198-202.

(i) The diameter of the circle is 99640 *yojanas*, the circumference is 315089 and a little over *(kiñcid-viśeṣādhika) (Sūrya-prajñapati, sūtra 20)*.

(ii) The diameter is 100000 *yojanas*, circumference is 316227 *yojanas* 3 *gavyutis* 128 *dhanus* 13½ *aṅgulas* and a little over *(kiñchid-viśeṣādhika) (Jambūdvīpa-prajñapti, sūtra 3)*.

Hence *viśeṣa* refers to a small quantity, which is either in excess or in deficit, and cannot be accurately determined. *Śulbakāras* gave no proof for it, since it was beyond their tradition.

Chapter 3

POSITIONS, RELATIVE DISTANCES AND AREAS OF SACRIFICIAL FIRES AND ALTARS

This and the following four chapters 4-7 deal with the positions, relative distances, and areas of various sacrificial fires and altars as also the types of bricks used in the construction of some of them. For a fuller appreciation of the details of mensuration presented by the *śulbakāras* in these chapters, a general idea regarding the plan of the sacrificial ground and the various fires and altars mentioned will be helpful. These details have been given at various places of the *Brāhmaṇas*, particularly of the *Yajurveda* school. Karavinda, the commentator of the *Āpastamba-Śulba-sūtra* has also made available a good summary.

Plan of the Sacrificial Ground

The place for worship and performance of the various sacrificial rites is selected where the ground is high, even and firm, inclining towards the east or the north and rising towards the south.[a] It should be spacious enough for the laying of the sacrificial hall, the *mahāvedi* and various pits, structures and elements required. After drawing the east-west line in the sacrificial ground, the sacrificial hall, the *prācina-vaṃśa* or *prāgvaṃśa*, as called by Baudhāyana, Kātyāyana and others, is erected at the western end, lying along, and symmetrically about, the east-west line (Fig. 26). The name is derived from the use of horizontal beams *(vaṃśa)* supported by four corner posts, on which corner beams are fastened to serve as lintels of the eastern and western doors.[b] In this hall, besides the priests, the members of the family and friends of the person performing the sacrifice can assemble.

Inside this sacrificial hall are set up the *gārhapatya* fire at the western end, the *āhavaniya* fire at the eastern, the *dakṣiṇāgni* on the southern side more towards west and the *utkara* on the northern side more towards east. In between the *āhavaniya*

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[a] *Śat. Br.* III. 1. 1. 1-3.
[b] *Śat. Br.*, III. 1.1.6 ; also see Eggeling's note, *SBE*, 26, 3.

and the *gārhapatya* fire is placed the *dārśapaurṇamāsika* altar for the full-moon sacrifice or such other altars as may be required.

The *gārhapatya* is the householder's fire received from his father and transmitted to his descendants. It is a perpetual sacred fire from which other sacrificial fires are lighted. This fire is used by the priests for cooking oblations.[a] The *āhavanīya* is a consecrated fire taken from the householder's perpetual fire and is also used for cooking oblations. The *dakṣiṇāgni*, also called by the name of *anvāhārya-pacana*, is used for cooking food. Eggeling says that, at the new-and full-moon sacrifice, the *anvāhārya* mess of rice, the priest's *dakṣiṇā*, is cooked at this fire. The *utkara* placed near the north-east side of the sacrificial hall is a rubbish pit dug out in the ground.

East of the *prāgvaṃśa* and separated by a narrow space, the *mahāvedi* or the *saumiki vedi* (the *soma* altar) is placed symmetrically about the east-west *(prācī)* line. This is a trapezium measuring 30 units on the western side, 24 on the eastern side and 36 units east-west along the spine. The setting up of the *mahāvedi* is described in the *Śatapatha Brāhmaṇa* as follows (Eggeling's translation)[b] :

"1. From the post which is the largest on the east side (of the hall) he now strides three steps forwards (to the east), and there drives in a peg,—this is the intermediate (peg).

2. From the middle peg he strides fifteen steps to the right, and there drives in a peg,—this is the right hip.

3. From the middle peg he strides fifteen steps northwards, and there drives in a peg,—this is the left hip.

4. From that middle peg he strides thirty-six steps eastwards, and there drives in a peg,—this is the fore-part.

5. From the middle peg (in front) he strides twelve steps to the right, and there drives in a peg,—this is the right shoulder.

6. From the middle peg he strides twelve steps to the north, and there drives in a peg,—this is the left shoulder. This is the measure of the altar."

After the area of the *mahāvedi* is thus marked out, the *sadas* tent is erected near the western base of the *mahāvedi*. The tent is rectangular in area, the longer side lying south-north symmetrically about the east-west line, and is provided with doors on the western and the eastern side. This tent is reserved for the priests to sit

[a] *Śat. Br.*, I. 1.2.23.
[b] III. 5.1. 3-6.
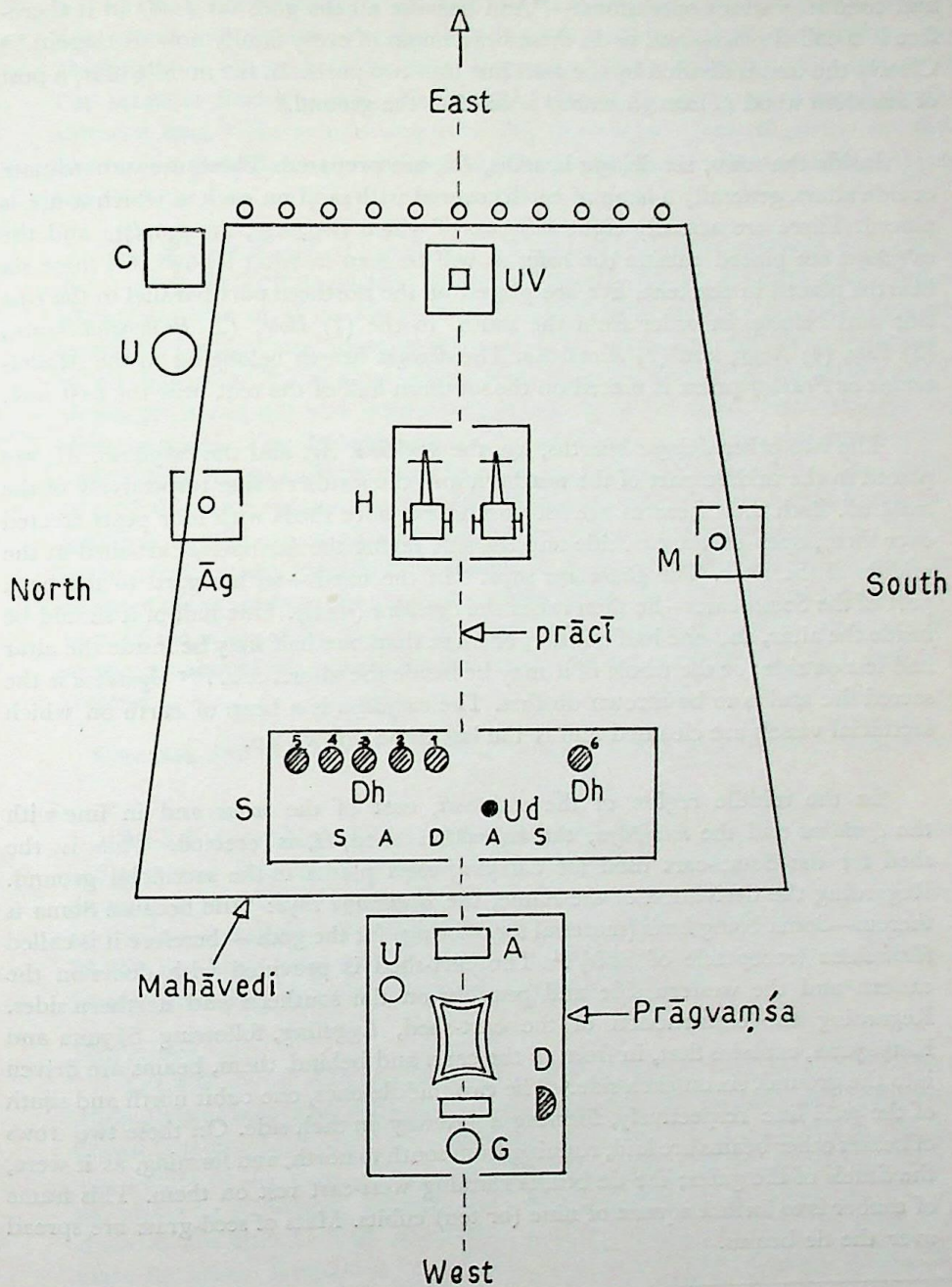
Fig. 26. Plan of the Sacrificial Ground.

and conduct various operations:—"And because all the gods sat *(sad)* in it therefore it is called *sadas*—and so do these Brāhmaṇas of every family now sit therein."[a] Clearly the tent is divided by the *prācī* line into two parts. In the middle of it, a post of *udumbara* wood *(Fiscus glomerata)* is fixed to the ground.[b]

Inside the *sadas*, six *dhiṣṇya* hearths, *Dh*, are prepared. These are subordinate or side altars, generally a heap of earth covered with sand on each of which a fire is placed. There are actually eight *dhiṣṇyas*, of which two, *e.g.*, the *āgnidhra* and the *mārjāliya* are placed outside the *sadas* as will be seen in what follows. Of these six hearths placed in the tent, five are placed on the northern part parallel to the east side and belong, in order from the south to the (1) *Hotṛ*, (2) *Brāhmaṇācchaṃsi*, (3) *Potṛ*, (4) *Neṣṭṛ*, and (5) *Acchāvāka*. The *dhiṣṇya* hearth belonging to the *Maitrāvaruṇa* or *Praśāstṛ* priest is placed on the southern half of the tent near the east side.

The two other *dhiṣṇya* hearths, *e.g.* the *āgnidhra*, *Āg*, and the *mārjāliya*, *M*, are placed in the middle part of the northern and the southern side respectively of the *mahāvedi*. Both these hearths are set up under square sheds with four posts erected over them, open on the east side and the side facing the *havirdhāna* cart-shed in the middle of the altar. The *Brāhmaṇa* says: "In the north—with regard to the back part of the Soma-carts—he then raises the *āgnīdhra* (shed). One half of it should be inside the altar, and one half outside; or more than one half may be inside the altar and less outside; or the whole of it may be inside the altar......."[c] *Āgnīdhra* is the sacred fire and is to be thrown up first. The *mārjālīya* is a heap of earth on which sacrificial vessels are cleansed and is the last to be thrown up.

In the middle region of the *mahāvedi*, east of the *sadas* and in line with the *āgnīdhra* and the *mārjāliya*, the *havirdhāna* shed, *H*, is erected. This is the shed for the Soma-cart used for carrying *soma* plants to the sacrificial ground. Regarding the derivation of the name, the *Brāhmaṇa* says: 'And because Soma is therein—Soma being *havis* (material for offering) for the gods—therefore it is called *Havirdhāna* (receptacle of *havis*)'.[d] The cart-shed is provided with doors on the eastern and the western side and possibly on the southern and northern sides. Regarding the construction of the cart-shed, Eggeling, following Sāyana and Kātyāyana, explains that, in front of the carts and behind them, beams are driven into the ground, six on each side.[e] The two middle ones, one cubit north and south of the *prācī* line respectively, forming a gateway on each side. On these two rows of beams other beams are laid, running from south to north, and forming, as it were, the lintels of the gates; the tie beams running west-east rest on them. This frame of timber is to form a square of nine (or ten) cubits. Mats of seed-grass are spread over the tie beams.

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[a] *Śat. Br.* III. 5. 3. 5.
[b] *Śat. Br.* III. 6. 1. 2.
[c] *Śat. Br.* III. 6. I. 26.
[d] *Śat. Br.* III. 5. 3. 2.
[e] *Śat. Br.* III. 5.3.9. Eggeling's notes, **SBE**, 27, 128.

Uparavas are sounding holes dug out in the ground near the *havirdhāna*. The *soma* plants are ground over this hole, emitting the sound of the grinding stone, which gave it the name. The exact location of these sounding holes is not clear. The *Śatapatha Brāhmaṇa* says: 'He digs just beneath the fore-part of the shafts of the southern cart.'[a] Karavinda says that the *uparavas* are located in the south-west corner of the southern part of the cart-shed,—*dakṣiṇahavirdhānasya dakṣiṇaśroṇyāmuparavāḥ*.

The *uttara vedi, UV*, is raised near the eastern side of the *mahāvedi*, with the *prāci* line passing through its middle. It literally means 'higher or upper altar' and so is likened to the nose of the sacrificer: 'That high altar *(uttara vedi)* is the nose oft he sacrificer; because they throw it up so as to be higher than the altar, therefore it is called 'high altar'.[b] The altar is built with the earth dug out of the *cātvāla* pit. This *cātvāla* pit is dug out at a little distance towards north from the north-east corner of the *mahāvedi*. The *Brāhmaṇa* says: '....and from where the northern peg of the front side is, he strides three steps backwards and there marks off the pit *(cātvāla)*.'[c] It is of the same measure as that of the *uttara vedi*. Karavinda's comments on the *cātvāla* is as follows: *uttarasmādvedyaṃsādudakprakrame cātvāla uttaravedisammitaḥ*. West of the *cātvāla* is the rubbish heap *utkara, U*. Eggeling has observed that the exact distance of the *cātvāla* is left to the discretion of the Adhvaryu priest, provided it is in front of the *utkara* and a narrow passage is left between them. He also says that the *cātvāla* pit should be contiguous to the north edge of the large altar, that is, the *mahāvedi*.

Distance and Relative Position of Gārhapatya, Āhavanīya, Dakṣiṇāgni and Utkara

3.1-3.5 According to Baudhāyana, the *āhavaniya* is constructed at a distance of 8 *prakramas* from the *gārhapatya* fire, when it is made by 4 Brāhmaṇas. The distance is sometimes 11 or 12 *prakramas* for peoples other than the Brāhmaṇas and followed traditionally from the time of the *Śatapatha Brāhmaṇa* (*Śat. Br.* I. 7.3. 23-25). For finding the relative positions of *gārhapatya, āhavaniya* and *dakṣiṇāgni* fires, Baudhāyana has prescribed the following three methods :

First method.

Let A, G, and D stand for *āhavaniya, gārhapatya* and *dakṣiṇāgni* fires. The distance AG is divided into three equal parts, and with each third part, three squares are drawn touching each other; then the north-west corner of the western square, south-east corner of the same square and north-east corner of the eastern square mark the places for *gārhapatya, dakṣiṇāgni* and *āhavaniya* fires respectively (Fig. 27). When A and G are interchanged the corresponding position of D i.e. U will denote the place for *utkara*. Kātyāyana has given a similar method for fixing the positions of A, G, D and U (vide *Kśl.* 1.11).

[a] *Śat. Br.* III. 5.4.3.
[b] *Śat. Br.* III. 5.1.12.
[c] *Śat. Br.* III. 5.1.26.
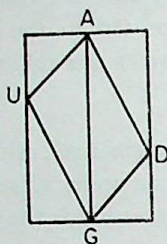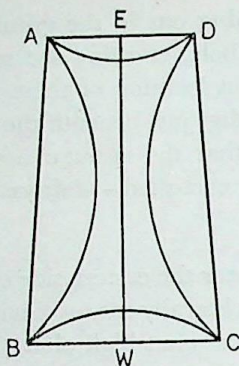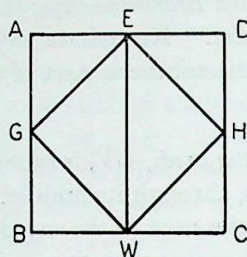
Fig. 27. Fig. 28. Fig. 29.

Here, if a be the distance between the *gārhapatya* and the *āhavaniya*, then

$$AD = \sqrt{\left(\frac{2}{3}a\right)^2 + \left(\frac{a}{3}\right)^2} = \frac{\sqrt{5}}{3}a$$

$$\text{and } GD = \sqrt{\left(\frac{a}{3}\right)^2 + \left(\frac{a}{3}\right)^2} = \frac{\sqrt{2}}{3}a$$

Second method.

According to this method,

$$AD = \frac{2}{3}\left(a + \frac{a}{7}\right) \text{ or } \frac{2}{3}\left(a + \frac{a}{6}\right)$$

$$= \frac{16}{21}a \text{ or } \frac{7}{9}a$$

$$\text{and } GD = \frac{8}{21}a \text{ or } \frac{7}{18}a$$

Third method.

$$\text{Here } AD = \frac{3}{5}\left(a + \frac{a}{5}\right) = \frac{18}{25}a$$

$$\text{and } GD = \frac{2}{5}\left(a + \frac{1}{5}\right) = \frac{12}{25}a.$$

The second method is given by Āpastamba (*Āśl.* 4.4) and the first method by Kātyāyana (*Kśl.* 1.11).

From these three methods, the approximate values of $\sqrt{5}$ and $\sqrt{2}$ have been calculated by Datta[a] as follows:—

$$\sqrt{5} = \frac{16}{7}, \frac{7}{3}, \frac{54}{25} = 2.285, 2.333, 2.16 \text{ respectively.}$$

$$\text{and } \sqrt{2} = \frac{8}{7}, \frac{7}{6}, \frac{36}{25} = 1.142, 1.166, 1.44 \text{ respectively.}$$

[a] Datta (2), 203-205.

The values $\sqrt{5} = 2.285$ and $\sqrt{2} = 1.44$ are correct upto first place of decimal and others are fairly approximate values.

Dārśapaurṇamāsika Vedi

3.6-3.8. The *dārśapaurṇamāsika vedi* is placed towards the west side of the *āhavanīya* and is in the form of an isosceles trapezium having face equal to 48 *aṅgulas,* base 64 *aṅgulas* and altitude 96 *aṅgulas.*

Here $AD = 48$ *aṅgulas*
$BC = 64$ *aṅgulas*
and $EW = 96$ *aṅgulas.*

A cord of length 2 BC is taken and a mark is given at its middle. Two ends of the cord are fixed at the southern poles A and B and is stretched towards south by the middle mark and a pole is fixed at it. Fixing two ends of the cord at this pole an arc is drawn through AB by the middle mark of the cord. Similar arcs are drawn in other sides. This is the *vedi* (Fig. 28).

This has been referred to in *Āśl.* 4.5 and *Mśl.* 1.4. The *vedi* has a long tradition and is mentioned in the *Taittirīya Saṃhitā* (II. 6.4. 2-3) and *Taittirīya Brāhmaṇa* (III. 2.9. 10).

Paśubandha and Uttara Vedi

3.9-3.10. The *paśubandha vedi* is in the form of an isosceles trapezium whose face equals 8 *padas,* base 10 *padas* and altitude 12 *padas.* Sometimes the *vedi* is measured by *akṣa, iṣā* and *yuga* units of a chariot. The *uttara vedi* according to Baudhāyana is a square pit of side 10 *padas.*

Paitṛkī Vedi

3.11. The *paitṛki vedi* is a square altar and its four corners are placed in four cardinal directions *viz.* east, west, north and south. The side of the *paitṛki vedi* is one-third of the units in *mahāvedi,* which is an isosceles trapezium of 972 sq. *padas,* having its face of 24 padas, base 30 *padas* and altitude 36 *padas.* Hence the corresponding units in *paitṛki vedi* are 8, 10, 12 and its area $\frac{1}{2}(8 + 10) \times 12 = 108$ sq. *padas.* This justifies Baudhāyana's statement that the *paitṛkī vedi* is one-ninth in area of the *mahāvedi.*

Again, when one-third of the *mahāvedi* (i.e. *sautrāmaṇiki vedi*) is turned into a square, its side becomes 18 *padas* (*Bśl.* 3.12). Baudhāyana says in this rule that the side of the *paitṛkī vedi* is $\frac{18}{\sqrt{3}}$. This is also quite proper, for by the first method the side of the *paitṛki vedi* equals $\sqrt{108}$ or $\frac{18}{\sqrt{3}}$.

Kātyāyana, however, prescribes that in a square $ABCD$ of 2 sq. *puruṣas,* the figure obtained by joining the middle poles $E, G, W, H,$ that is the figure $EGWH$ will be the required *paitṛki vedi.* The area $EGWH$ is undoubtedly a square of 1 sq.

puruṣa(Fig. 29). Here again the area varies from that of Baudhāyana but agrees with that of Āpastamba (*Āśl.* 6.7-6.8). Though there is some difference in area, it is, however, a fact that the *paitṛki vedi* is a square pointing towards the cardinal directions.

Sautrāmaṇiki Vedi

3.12. The rule of Baudhāyana suggests that the *Sautrāmaṇiki vedi* may be a square of 18 *padas* or an isosceles trapezium whose area is one-third of that of *mahāvedi,* having area of 972 sq. *padas*. Baudhāyana made no explicit mention of how to construct an isosceles trapezium similar to a given isosceles trapezium but with one-third of its area. Āpastamba (*Āśl.* 5.8) constructed it with $\frac{1}{\sqrt{3}}$ of the units used in *mahāvedi* or $8\sqrt{3}$ and $10\sqrt{3}$ as face and base and $12\sqrt{3}$ as altitude. The *mahāvedi* is an isosceles trapezium having face 24, base 30 and altitude 36 units. Hence the *sautrāmaṇikī vedi* is an isosceles trapezium of face $\frac{24}{\sqrt{3}}$ or $8\sqrt{3}$, base $\frac{30}{\sqrt{3}}$ or $10\sqrt{3}$, and altitude $\frac{36}{\sqrt{3}}$ or $12\sqrt{3}$. Hence the area of the figure in the above two cases comes out as,

(i) $$\frac{1}{2}\left(\frac{24}{\sqrt{3}}+\frac{30}{\sqrt{3}}\right)\times\frac{36}{\sqrt{3}}=\frac{1}{2}\cdot\frac{54}{\sqrt{3}}\cdot\frac{36}{\sqrt{3}}$$

and (ii) $$\frac{1}{2}\left(8\sqrt{3}+10\sqrt{3}\right)\times 12\sqrt{3}=324.$$

This equals one-third the area of a *mahāvedi*. The same method is also given by Kātyāyana (*Kśl.* 2.11-2.12).

Chapter 4

AREAS OF *PRĀGVAMŚA*, *MĀHĀVEDI*, *SADAS*, ETC., THEIR RELATIVE DISTANCES; CONSTRUCTION OF *EKĀDAŚĪ AND AŚVAMEDHA VEDI*, AND THE VALUE OF π

4.1-4.11. The areas of different chambers and *vedis* as given by Baudhāyana are tabulated below :

Name of altar	*Geometrical shape*	*Measurement*
āgnidhriya	square	side = 5 *aratnis.*
cātvāla	square	side = 36 *aṅgulas.*
dhiṣṇas	circle	diameter = 2 *prādeśas.*
havirdhāna	square	side = 10 or 12 *prakramas.*
mahāvedi	isosceles trapezium	face = 24 *padas,* base = 30 *padas,* altitude = 36 *padas,*; the units may be also in *prakramas.*
mārjāliya	square	side = 5 *aratnis.*
prāgvaṃśa	rectangle	length = 16 *prakramas,* breadth = 12 *prakramas;* or length = 12 *prakramas,* breadth = 10 *prakramas.*
sadas	rectangle	length = 27 *aratnis,* breadth = 10 *prakramas ;* or length = 18 *aratnis,* breadth = 10 *prakramas.*

The *uparavā* is a square of side 12 *aṅg.* or a circle of radius 6 *aṅg.* drawn within a square of side 24 *aṅg.* Two *uparavās* are generally placed together at a distance of 12 *aṅgulas.*

The rites and ceremonies in connection with the construction of the above and various other altars are commonly found in the *Taittiriya Saṃhitā* and *Śatapatha Brāhmaṇa*, but any clear mention of their special magnitudes is very rare.

Baudhāyana has made categorical mention of spatial magnitudes besides the methods of construction here and there (*Bśl.* 7.9, *Āśl.* 7.2.). Baudhāyana has discussed the construction of the *mahāvedi* in the next rule. Āpastamba has specially treated the dimension, area and construction of *mahāvedi* (or *saumiki vedi*) in chapter 5 of his *Āpastamba-śulbasūtra*. The *mahāvedi* has much older tradition and its method of construction is mentioned in the *Śatapatha Brāhmaṇa* (IX. 2.1.4).

As regards relative distance of other *vedis* within the *mahāvedi* it is known from the *Baudhāyana śulba* that the *sadas* is at a distance of 1 *prakrama* (or *pada*) from the

western side of the *mahāvedi*, and the *havirdhāna* at a distance of 4 *prakramas* (or *padas*) from it, and in the eastern side of the *havirdhāna*, 9 prakramas (or *padas*) still remain. Hence the relative distance is 1 + 10 *(sadas)* + 4 + 12 *(havirdhāna)* + 9 (rest) = 36. According to Mānava (*Mśl.* 3.1-3.3), this is 1 + 9 *(sadas)* + 4 + 12 + 10 = 36. In this connection it is important to note that the altitude of the *mahāvedi* is 36.

Use of Ekādaśinī in the Construction of Mahāvedi and Aśvamedha Vedi

4.12-4.14. In *ekādaśini vedi* there are 11 posts arranged in a row, each placed at a distance of 1 *akṣa* from its immediate next. The diameter of each hole in which the pole is placed is a *paḍa*, and a space of 4 *aṅg.* is left on both sides of the two end-poles. Hence the space covered equals 10 *akṣa* + 11 *padas* + 8 *aṅg.* that is, 1213 *aṅg.* For the construction of the eastern part (i.e. face) of the *mahāvedi* with 11 poles, the length of 1213 *aṅg.* is divided by 24 to calculate the value of each *prakrama*. The distance between the two poles is known as *prakrama*. The length of *prakrama* varies for enlarged altars. For this reason the length of *prakrama* in *mahāvedi* is different from that of *aśvamedha vedi*. Since the face of the *mahāvedi* is 24 *prakramas*, according to Dvārakānātha, one *prakrama* equals

$$\frac{10 \times 104 + 11 \times 15 + 4}{24} = 50 \text{ } a\dot{n}g. \ 18 \text{ } tilas \text{ (approx.)}.$$

According to Kātyāyana (*Kśl.* 6.8-6.13), it is the 24th part of 11 *paravān*, 10 *akṣa* that is, 48 *aṅg.* 28 *tilas* (Mahīdhara). Kātyāyana has not considered any space left beyond the two-poles. Mahīdhara has suggested 1 *paravān* to be 12 *aṅg.*; the *pada* according to Baudhāyana is 15 *aṅg.*, while it is 12 *aṅg.* in other texts.
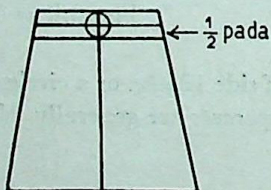
Fig. 30.

The east-west line *(prāci)* of the *mahāvedi* is likewise constructed with 11 poles. Only a rectangular block of half a *pada* is cut off from the eastern side of the altar and the end-pole is placed, so that half of the end-pole is to be considered inside the altar and half outside. For construction of east-west line, the extra 8 *aṅg.* that is left beyond the end-poles discussed above is not required in this case.

For the construction of the *aśvamedha vedi*, by the use of 21 poles, the value of each *prakrama* is taken to be 24th part of 20 *akṣa* + 21 *padas* + 8 *aṅg.* which is equal to $\frac{20 \times 104 + 21 \times 15 + 8}{24}$ = 100 *aṅg* 4 *tilas* (approx.).

Value of π

4.15. If d be the diameter of each hole (required in the construction of altar), and c its circumference, then according to this *sūtra*,

$$\text{(i) } \pi = \frac{c}{d} = 3.$$

This is undoubtedly a rough value known to the *śulbakāras*. In the problem of circling a square and quadrature of the circle, Baudhāyana has given three other values, which are a little better when compared with the correct value of π (= 3.14159...) as will be evident from the following :

$$\text{(ii) } \pi = \frac{4}{r^2} = 3.0883......$$

$$\text{where } r = 1 + \frac{1}{3}(\sqrt{2} - 1);$$

$$\text{(iii) } \pi = 4\left(1 - \frac{1}{8} + \frac{1}{8.29} - \frac{1}{8.29.6} + \frac{1}{8.29.6.8}\right) = 3.0885 \text{ ;}$$

$$\text{and (iv) } \pi = 4\left(1 - \frac{2}{15}\right)^2 = 3.004.$$

Dvārakānātha[a] has, however, improved upon results (ii) and (iii) by introducing certain corrections as follows :

$$\pi = \frac{4}{\left[1 + \frac{1}{3}(\sqrt{2} - 1)\right]^2} \times \left(\frac{118}{117}\right)^2 = 3.141109......$$

$$\text{and } \pi = 4\left(1 - \frac{1}{8} + \frac{1}{8.29} - \frac{1}{8.29.6} + \frac{1}{8.29.6.8.}\right)^2 \times \left(1 + \frac{1}{2}\cdot\frac{3}{133}\right)^2$$
$$= 3.157991.$$

Chapters 5, 6 and 7

ENLARGEMENT OF FIRE-ALTAR FROM 7½ SQ. *PURUṢAS* TO 101½ SQ. *PURUṢAS*, HEIGHT OF ALTARS AND THEIR PECULIARITIES

Enlarged Fire-altar and Units

5.1-5.6. The *fire-altar* of the first construction has an area of 7½ sq. *puruṣas*. This has been discussed in subsequent chapters. The second construction has 8½sq. *puruṣas*, and according to Baudhāyana, it is increased by one square *puruṣa* successively from 7½ sq. *puruṣas* to 101½ sq. *puruṣas*. There is a mention of this type of

[a] Datta (2), 149.

increment upto $101\frac{1}{2}$ sq. *puruṣas* in the *Śatapatha Brāhmaṇa*[a]. When the *fire-altar* is increased from the original $7\frac{1}{2}$ sq. *puruṣas* by *p* square *puruṣas*, Baudhāyana says, the increment in each *puruṣa* equals the side of a square of $1 + \frac{2p.}{15}$ sq. *puruṣas*. Hence the enlarged unit equals $\sqrt{1 + \frac{2p}{15}}$ and the area of the enlarged fire-altar

$$7\tfrac{1}{2}\left(1 + \frac{2p}{15}\right) \text{ that is, } 7\tfrac{1}{2} + p. \text{ sq. } \textit{puruṣas} \; (\textit{Bśl. } 5.6).$$

With this length as unit of measure, the altar is constructed in the same manner as in original falcon-shaped altar. For obtaining the portion $\frac{2p}{15}$, Baudhāyana perhaps divided the extra area into 15 equal parts by drawing 15 parallel lines or by drawing 3 parallel lines in one side and 5 parallel lines on the other after *p* square areas were turned into a square. Then two of these rectangular pieces were combined together with the help of *samāsavidi*.

Both Āpastamba (*Āśl.* 8.6) and Kātyāyana (*Kśl.* 5.5) have given the same value of Baudhāyana, which equals the side of a square of $\frac{2}{15}(7\frac{1}{2} + p)$ sq. *puruṣas* (where $p = 1$ sq. *puruṣa*). Kātyāyana has given the same value of enlarged sq. unit in two other forms as follows :

$$\text{(i) } 1 + p\left(\frac{5}{5.5} - \frac{1}{3}\cdot\frac{5}{5.5}\right) = 1 + \frac{2p}{15} \quad (\textit{Kśl. } 5.7);$$

$$\text{and (ii) } 1 + p\left(\frac{7}{7.7} - 1 \times \frac{1\frac{1}{7}}{120}\right) = 1 + \frac{2p}{15} \quad (\textit{Kśl. } 5.7);$$

where $p = 1$.

This method of Kātyāyana is known as the method of increment by *puruṣa* (*puruṣābhyāsa—Kśl.* 5.4).

Moreover, Āpastamba has devised a method of joining complete *puruṣas* in the body, wings and tail. If the increased area of *p puruṣas* be an exact mutiple or sub-multiple of the original *agni*, i.e. $p = q \times 7\frac{1}{2}$, then the new unit comes out to be $\sqrt{1 + q}$. This is known as increment on the whole posts (*sarvābhyāsa, Āśl.* 21.7).

In the enlargement of the falcon-shaped fire-altar (first plan) let s be the enlarged unit in *puruṣa* and p the total increment in area. Then in the form of a quadratic equation this can be written as

$$\text{body} + 2 \text{ wings} + \text{tail} = 7\tfrac{1}{2} + p$$

$$\text{or} \quad 4s^2 + 2s\left(s + \frac{s}{5}\right) + s\left(s + \frac{s}{10}\right) = 7\tfrac{1}{2} + p$$

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[a] *saptavidhameva prathamaṃ vidadhitāthathaikottaramaikaśatavidhādekaśatavidhaṃ* (*Śat. Br*, X. 2.3. 17-18).

$$\text{or} \quad 4s^2 + \frac{12}{5}s^2 + \frac{11}{10}s^2 = 7\tfrac{1}{2} + p$$

$$\text{or} \quad \frac{15}{2}s^2 = 7\tfrac{1}{2} + p$$

$$\text{or} \quad s^2 = \frac{2}{15}(7\tfrac{1}{2} + p) = 1 + \frac{2p}{15}$$

$$\text{or } s = \sqrt{1 + \frac{2p}{15}}$$

when $p = 94$, the maximum enlargement,

$$s = 13\frac{8}{15} = 14 \text{ approx.}$$

The principle of enlargement of *agni* by increasing the length of the unit of measure was known in the time of the *Śatapatha Brāhmaṇa*.[a] It has described the construction of the *agni* of $101\frac{1}{2}$ sq. *puruṣa,* where 14 or $14\frac{3}{4}$ times enlarged unit in *puruṣa* is taken up for its construction.[b]

Height and Characteristics of Different Layers of Altar and Bricks

5.7-7.3. In the usual five-layer construction, the height of the altar is 32 *aṅg.*, height of each layer being $\frac{32}{5}$ *aṅg.* (*Bśl.* 5.7 and 7.2). According to Karavindasvāmī, it is 6 *aṅg.* Actually two layers are constructed. Construction of other layers is not required, since the 3rd and the 5th layer are the replica of the 1st and the 4th that of the 2nd. In the placement of bricks in different layers clefts between two layers are avoided. An altar of daily fire like the *gārhapatya* has 21 bricks in each layer, while a *kāmya* fire-altar is constructed with 1000 bricks, each layer containing 200 bricks. A fire-altar of $7\frac{1}{2}$ sq. *puruṣas* is the normal construction. *Pañcacoḍā* and *nākasat* bricks have half the thickness of ordinary bricks ; hence one *pañcacoḍā* and one *nāksat* taken together are considered as one brick (*Bśl.* 5.17 and 7.2). They are usually on the fifth layer placed at the top. The spoiled or broken bricks or bricks of black colour are not used in the construction (*Bśl.* 7.1).

Usually all the fire-altars from $1\frac{1}{2}$ sq. *puruṣas* (one fold) to $101\frac{1}{2}$ sq. *puruṣas* (101 fold) are not constructed. In some cases they are constructed without wings and tails.

In the construction of fire-altars from $8\frac{1}{2}$ to $101\frac{1}{2}$ sq. *puruṣas,* how the units in sq. *puruṣas* are proportionately increased has been discussed. After all these are not normal constructions and are done in the construction for second and third time. In the second and third construction the fire-altar is constructed with more bricks and increased height. As regards its height and the number of bricks to be used in its construction, the *Taittiriya Saṃhitā* writes: "He should pile (the fire) of a thousand (bricks) when first piling (it); this world is commensurate with a thousand; verily he conquers this world. He should pile (it) of two thousands, when piling a second time, the atmosphere is commensurate with two thousands; verily he

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[a] *Śat. Br.* X.2.3. 11-14. Eggeling's trn. is incorrect.

[b] Datta (2), 159-60.

conquers the atmosphere. He should pile (it) of three thousands, verily he conquers yonder world. Knee-deep should he pile (it) when piling for the first time, verily with the *gāyatri* he mounts this world; naval-deep should he pile it when piling for the second time, verily with the *triṣṭubh,* he mounts the atmosphere; neck-deep should he pile (it) when piling for the third time, verily with the *jagati,* he mounts the yonder world".[a] (Keith's translation).

The fire-altar (Chapter 6) has the characteristics of an animal. The head of the animal lies in the east and its back is compared with the east-west line. The east-west line is the central line of the altar and measurements are given with reference to this central east-west line. The bricks marked for south and north are placed accordingly on the southern and northern side of the altar. Diagrams of circle, a bull, a woman without ears, line, *darbha* grass are depicted on the bricks for their use for specific purposes. The bricks with different markings and symbols are also mentioned by Mānava in Chapter 7 of his *Mānava-śulbasūtra.*

Construction of Gārhapatya Fire-altar (Square).

7.4-7.7. Baudhāyana says the *gārhapatya* fire-altar has the form of a square according to one tradition and of a circle according to another. The area is always one sq. *vyāyāma.* It is constructed with 21 bricks in each layer. For the placing of bricks in the square *gārhapatya,* the following two methods are adopted.

First Method.

One side of the square is divided into 3 parts by drawing 3 parallel lines and the other into 7 parts by drawing 7 parallel lines. These lines divide the square area into 21 rectangles and the bricks are accordingly made. This is for the first layer. For the second layer, the bricks are arranged differently in the square.

Second Method.

Three kinds of square bricks are made with 6th, 4th and 3rd part of a *vyāyāma.* The first layer is prepared with 9 bricks of the first kind and 12 bricks of the second, and the second layer with 6 bricks of the third kind and 16 bricks of the first.

How the ancient altar builders determined the size of the bricks of different kinds and the number of bricks of each kind required for the construction of each layer is not known. The solution was obtained possibly on the following line.[b]

Empirical Method.

Suppose the sides of the three new types of bricks be p, q, and r th part of a *vyāyāma,* where p, q, r are rational integers. The minimum number of bricks must be three, since in each layer there are two types of square bricks and no two layers have identical arrangement of bricks.

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[a] *sahasraṃ cinvīta prathamaṃ cinvānaḥ, sahasrasaṃmito vā avaṃ loka imameva lokamabhi jayati, dvisahasraṃ cinvīta dvitīyaṃ cinvāno, dvisahasraṃ vā antarikṣamantarikṣamevābhi jayati; trisahasraṃ cinvīta tṛtīyaṃ cinvānastṛsahasro va asau loke'mumeva lokamabhi jayati | jānudaghnaṃ cinvīta prathamaṃ cinvāno. . . nābhidaghnaṃ cinvīta dvitīyaṃ. . . grīvādaghnaṃ cinvīta tṛtiyaṃ* (*Tait.* S.V. 6.8.2-3.

[b] Datta (2), 180-183.

Let the first layer have m number of bricks of the first kind and n bricks of the second kind, so that

$$\left.\begin{aligned} m + n &= 21 \\ \text{and} \quad \frac{m}{p^2} + \frac{n}{q^2} &= 1 \end{aligned}\right\} \quad .. \qquad (1)$$

Similarly we can have another set of equations, if the second layer consists of s bricks of the third kind and t bricks of the first kind, as follows :

$$\left.\begin{aligned} s + t &= 21 \\ \frac{s}{r^2} + \frac{t}{p^2} &= 1 \end{aligned}\right\} \quad .. \qquad (2)$$

Baudhāyana's solutions are :

(i) $x = 9, y = 12, p = 6, q = 4$

(ii) $x = 5, y = 16, p = 3, q = 6$

These two sets of values obviously satisfy equations (1) and (2) respectively.

Solutions of equations (1) and (2) lead to the problem of solution of the simultaneous indeterminate equation of the type:

$$\left.\begin{aligned} \frac{x}{p^2} + \frac{y}{q^2} &= 1 \\ x + y &= 21 \end{aligned}\right\} \quad ... \qquad (3)$$

Solving three, we write :

$$x = \frac{p^2 (21 - q^2)}{p^2 - q^2}, \quad y = \frac{q^2 (p^2 - 21)}{p^2 - q^2}$$

The numbers x and y are considered positive by the *śulbakāras*. Hence

if $p > q, \; p^2 > 21 > q^2$

since, $s^2 > 21 > 4^2, p \geq 5, \; q \leqslant 4$

if $p < q, \; q \geqslant 5, p \leqslant 4$

Putting $q = 1, 2, 3, 4$, the values of p can be determined by trial, considering the value of x to be integral.

Construction of Gārhapatya Fire-altar (Circular)

7.8. For construction of a circular *gārhapatya* a square $ABCD$ as large as possible is inscribed within a circle (Fig. 31) Āpastamba has directed that with half a *vyāyāma* as radius this circle is to be drawn; the end points of two diameters standing at right-angles to each other when joined give the largest possible square (*Āśl.* 7.5.).

The square *ABCD* is then divided into 9 equal parts by 3 parallel lines from one side and 3 from the other side, and each segment is divided into 3 equal parts. Hence the whole circle is divided into 21 parts and the bricks are accordingly made for the first layer.
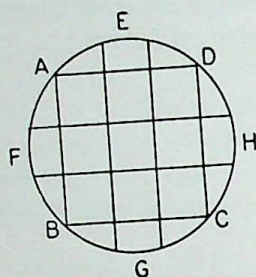
Fig. 31
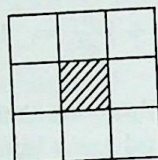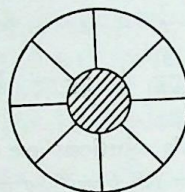
Fig. 32

In the second layer the square is so adjusted that the corners *A, B, C,* and *D* are placed in the middle points *E, F, G* and *H* of the segments.

Baudhāyana and Āpastamba have considered the problem of quadrature of the circle whose area falls short of the circle.

Construction of Dhiṣṇya, Āgnīdhrīya, Mārjālīya and Chanda Fire-altars.

7.9-7.17. The *dhiṣṇya* has one layer only. It may be a square or a circle. Generally it is covered with sand on which the fire is placed.

The *āgnidhriya* may also be a square or a circle. When it is in the form of a square, it is divided into nine small squares, and the central brick is replaced by a piece of stone. The same method is also given by Mānava (*Mśl.* 6.10). When it is circular, a round stone of 8 *aṅgulas* diameter is placed in the centre of the circle and the remaining area divided into eight equal parts (Fig. 32).

The *mārjāliya* is divided into 3 equal parts by lines parallel to the north-south line. The eastern and western parts together are divided into 5 parts. No detail is available in the *Baudhāyana śulba* as to how the eastern or western part is to be divided. The commentator Dvārakānātha gives the idea of dividing the eastern slab into two and western slab into three parts. Mānava has, however, suggested different constructions (*Mśl.* 6.11). The *mārjāliya,* when circular, is divided into six equal parts.

The *chandaścit* is the fire-altar of *mantras,* not of bricks. The shape of the fire-altar is drawn on the ground and the whole ceremony performed. Instead of placing bricks, the sacrificer only touches the places on which the bricks are to be placed and mutters the same *mantras* at the appropriate time.

CHAPTER 8

CONSTRUCTION OF A RECTILINEAR *ŚYENACIT*—FIRST TYPE

8.1.-8.5. Baudhāyana, Āpastamba and other *śulbakāras* have considered the construction of two categories of falcon-shaped fire-altars. e.g. (a) the first category in which the body, the wings and the tail are rectilinear (squares and rectangles), and (b) the second category in which the wings are curved, the tail is spread out, and the body and the head have their corners cut off. In the latter case the shape of the altar more closely resembles the falcon.

The *sūtra* 8.4 is taken from the *Taittirīya Saṃhitā* which runs as follows : *pañca dakṣiṇāyāṃ śroṇyāmupadadhāti / pañcottarasyāṃ tasmāt paścādvarṣiyān purastāt pravaṇaḥ paśubasto vaya iti dakṣiṇe'ṃsa upadadhāti / vṛṣṇirvaya ityuttare'ṃsāveva pratidadhāti / vyāghro vaya iti dakṣiṇe pakṣa upadadhāti / siṃhovaya ityuttare pakṣayoreva vīryaṃ dadhāti / puruṣo vaya iti madhye tasmāt puruṣaḥ paśunāmadhipatiḥ*[a] /

The construction of the fire-altar after the shadow cast on the ground by a flying bird is also given in the same *Brāhmaṇa* as follows : *vayasāṃ vā eṣa pratimayā ciyate yadagniryannyāñcaṃ cinuyāt*[b] /

In this chapter, a simple rectilinear *śyenacit* is discussed.

8.6-8.7. *Bricks*. The following four types of square bricks are used for the construction:

B_1—one-fourth brick (*caturthī*) —30 × 30 sq. *aṅgulas.*
B_2—one-fifth brick (*pañcamī*)—24 × 24 sq. *aṅgulas.*
B_3—one-sixth brick (*ṣaṣṭhī*) —20 × 20 sq. *aṅgulas.*
B_4—one-tenth brick (*daśamī*) —12 × 12 sq. *aṅgulas.*

8.8-8.10. *Measurement of the fire-altar*. In this fire-altar, the body (*ātman*) is a square and the two wings and the tail are rectangles. To set up these rectilinear figures of required areas on the ground, one can use either a cord or a bamboo rod and follow the rules of construction of such figures discussed in chapters 1 and 2. For measurement with a bomboo rod with a hole at either end and at the middle, Āpastamba has given greater details which are considered in our notes to *Āśl.* 9.1-9.3.

The body is a square of 4 sq. *pu.*, that is, of side 2 *pu.* or 240 *aṅg.* At the middle of its southern and northern side, a rectangle each, measuring 144 *aṅgulas* × 120 *aṅgulas,* with the longer side drawn south-north, is set up; this will represent the south and the north wing. A rectangle of 132 *aṅgulas* × 120 *aṅgulas,* with the longer side towards east-west, attached to the middle of the western side of the body, is the tail (Fig. 33). The area of the altar is :

$$\frac{1}{120^2}\left[\ 240^2 + 2 \times 144 \times 120 + 132 \times 120\ \right] = 7\tfrac{1}{2} \text{ sq. } \textit{puruṣas} \text{ as required}$$

in the text.

[a] *Taitt. S.* 5.3.1.5.
[b] *Taitt. S.* 5.5.3.2.

8.11-8.13. *Placement of bricks in the first layer.* Starting with the south wing, 4 B_2 bricks flanked on either side by 2 B_4 bricks are placed in a row, east-west, at a distance of 40 *aṅgulas* from the end of the wing (Fig. 33). Dvārakānātha explains *puruṣatṛtiya-velāyām* as *catvāriṃśadaṅgulapramāṇavelāyāmatītāyām*. Then 8 B_1s are placed in two rows, leaving a space which can be filled exactly by 18 B_3 bricks. In this way, 34 bricks can be placed in the south wing *(evaṃ pakṣe catustriṃśadiṣṭakāḥ.* The northern wing is covered in the same way starting with the northern end.

Fig. 33. Arrangement of bricks in the first layer of a *caturaśra śyenacit* (northern wing not shown).

In the tail, as per direction of the rule, 8 B_1s can be placed, —4 on the eastern and 4 on the western side, 12 B_4s—6 on the southern and 6 on the northern side, and 12 B_2s in the remaining space in the middle, accounting for 32 bricks *(pucche dvātriṃśat*—D.). Rule 8.12 also directs the filling up of the body with B_2 bricks, and clearly enough 100 B_2s can be accommodated in a square 240 × 240 sq. *aṅgulas* (*ātmani śatam*—D.). The number and types of bricks used in different parts of the fire-altar are shown in Table 1, in agreement with Dvārakānātha's enumeration *(caturthyaścaturviṃśatiḥ / pañcamyo viṃśatyadhikaṃ śatam / ṣaṣṭhyaḥ ṣaṭtriṃśat / daśamyo viṃśatiḥ /).*

8.14-8.18 *Placement of bricks in the second layer.* The arrangement of bricks is shown in Fig. 34. After leaving 48 *aṅgulas* at the end of the southern wing, 3 B_3s are placed at the western and the eastern side each towards north, and 3 B_3s in the middle; the space (that is, two rows, south-north) in between these three rows is filled with 4 B_1s. D. explains this placement as follows: *aratnidvaye'tīte pakṣapaścimapārśva udīcyastisraḥ*

TABLE 1. *Bricks in different parts of the citi—first layer.*

Parts of the *citi*	Brick types				Total
	1	2	3	4	
Body		100			100
Wings	16	8	36	8	68
Tail	8	12		12	32
Total	24	120	36	20	200

ṣaṣṭhyastataḥ purastāddakṣiṇottare dve dve dvipade / tatastisraḥ ṣaṣṭhyaḥ / tato dve dvipade / tataḥ pūrvapārśve tisraḥ ṣaṣṭhyaḥ /
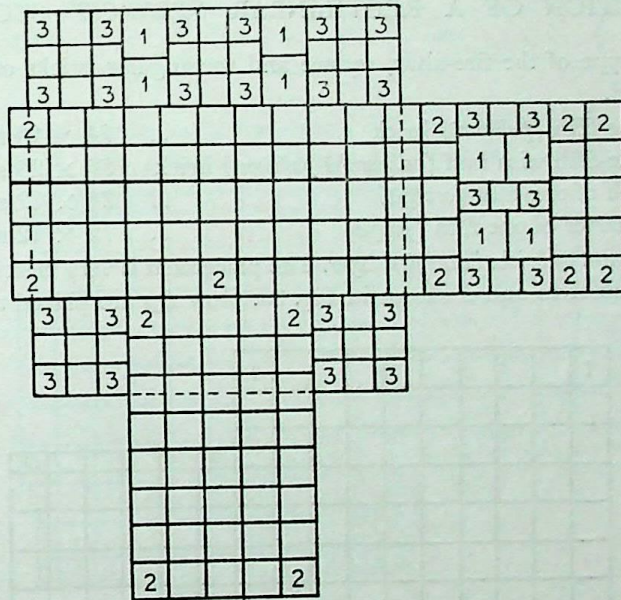
Fig. 34 Arrangement of bricks in the second layer of a *caturaśra śyenacit* (north wing not shown).

In the body, 9 B_3 bricks are placed in a square 60 × 60 sq. *aṅgulas* at each of the two western corners. On the eastern side of the body, 9 B_3s, arranged in a square, are placed in each of the two eastern corners, one such set of 9 B_3s in the middle, and the two rows east-west, in between these 3 sets are filled by 4 B_1 bricks, 2 in each row. The remaining space is covered with B_2 bricks. Notice that the overlapping of edges of the bricks in the two layers has been clearly avoided (*Bśl.* 5. 14). The arrangement of different types of bricks in different parts of the fire-altar is shown in Table 2.

TABLE 2. *Bricks in different parts of the citi—second layer.*

Parts of the *citi*	Brick types			Total
	B_1	B_2	B_3	
Body	4	55	45	104
Wings, including bricks partly covering body	8	40	18	66
Tail, including bricks partly covering body		30		30
Total	12	125	63	200

CHAPTER 9

CONSTRUCTION OF A RECTILINEAR *ŚYENACIT*—SECOND TYPE

9.2. In this type of the fire-altar, square and rectangular bricks of the following types are used.

B_1 — one-fifth *(pañcamī)* brick .. 24 × 24 sq. *aṅgulas.*
B_2 — one-fifth with half *(adhyardhā-pañcamī)* brick 36 × 24 sq. *aṅgulas.*
B_3 — half of one-fifth *(ardhyā)* .. 24 × 12 sq. *aṅgulas.*
B_4 — quarter of one fifth *(pādyā)* .. 12 × 12 sq. *aṅgulas.*

9.3-9.6. *Placement of bricks in the first layer.* The placement is very clearly explained in the *sūtras* themselves and is shown in Fig. 35. How B_3s are placed turned towards
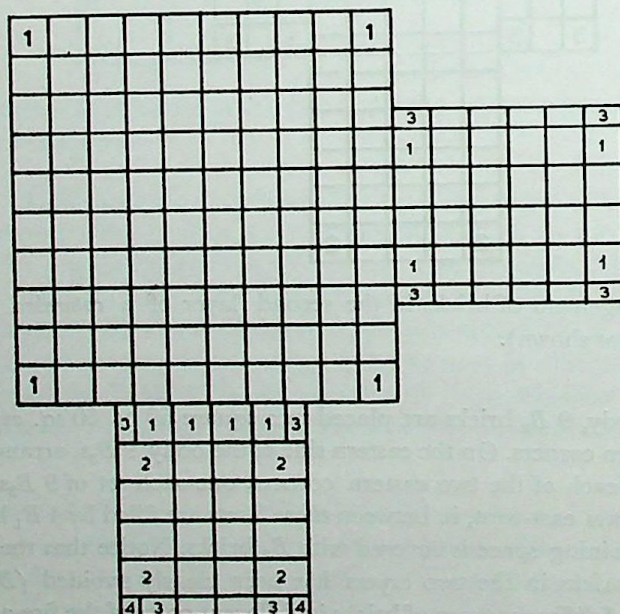
Fig. 35. Arrangement of bricks in the first layer.

north *(udiciḥ)* on the western and eastern side of the wings and at the end of the tail, and towards east *(prācim)* at the two corners of the tail where it joins with the body, should be noticed. Regarding the number and types of bricks used in the different parts of the fire-altar, D. comments as follows: *tatra pakṣayordvisaptatiḥ / aṣṭāviṃśatiḥ pucche / ātmani śatam / asminprastāre ṣaṣṭiḥ śataṃ pañcamyaḥ / aṣṭāvadhyardhāḥ / triṃśa-dardhyāḥ / dve pādeṣṭake /* (Table 3.).

TABLE 3. *Bricks in the first layer*

Parts of the *citi*	Brick type				Total
	B_1	B_2	B_3	B_4	
Body	100				100
Wings	48		24		72
Tail	12	8	6	2	28
Total	160	8	30	2	200

9.7-9.10. *Placement of bricks in the second layer.* Here, after placing 1 B_4 at each of the four corners of the body, 2 B_3s are on either side of each B_4. With 5 B_3s in the middle
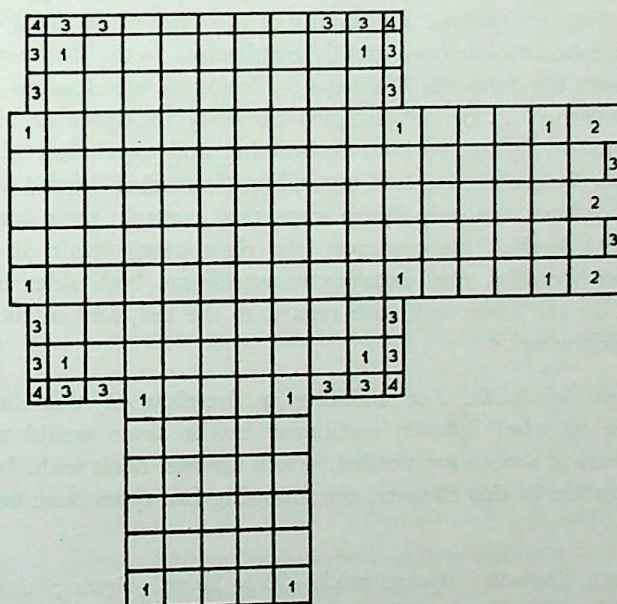
Fig. 36. Arrangement of bricks in the second layer.

of the eastern side, their total number on the eastern side is actually 9. The alternate arrangement of 3 B_2s and 2 B_3s at the end of the wing is shown in the Fig.36. The number and types of bricks used in covering the second layer are shown in Table 4 and agree with D's commentary : *asminprastāre pañcaṣaṣṭiḥ śataṃ pañcamyaḥ / ṣaḍadh-yardhāḥ / pañcaviṃśatirardhāḥ / catasraḥ pādyāḥ /*

TABLE 4 . *Bricks in the second layer.*

Parts of the *citi*	Brick type				Total
	B_1	B_2	B_3	B_4	
Body, excluding junction layers	81		21	4	106
Wings, including junction layers	54	6	4		64
Tail, including junction layer	30				30
Total	165	6	25	4	200

CHAPTER 10

CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A FALCON WITH CURVED WINGS AND EXTENDED TAIL—FIRST TYPE.

10.1. This type of fire-altar is constructed more in the likeness of a falcon. To achieve this the two wings are to be curved or bent and the tail is to be extended, that is, spread out. The body *(ātman)* itself should be cut out at its four corners, and there should be a head. The end of each wing is serrated to give it the appearance of being provided with feathers *(patra)*. The laying of this type of fire-altar on the part of those who desire heaven has been greatly emphasized in the *Brāhmaṇas*. Here are a few excerpts from the *Śatapatha Brāhmaṇa* : "Prajāpati was desirous of going up to the world of heaven ;...... He saw this bird-like body, the fire-altar, and constructed it. He attempted to fly up, without contracting and expanding (the wings), but could not do so. By contracting and expanding (the wings) he did fly up : whence even to this day birds can only fly up when they contract their wings and spread their feathers"[a] . Again, "He contracts (the right wing) inside on both sides by just four finger-breadths, and expands it outside on both sides by four finger-breadths;...... In the same way with regard to the tail, and in the same way in regard to the left wing."[b]

10.2-10.3. *Types of bricks.* For building a fire-altar of this shape which is fully described in what follows, rectilinear bricks alone would not do. Bricks of other geometrical shapes are needed, which are first dealt with. In the first type under consideration in this chapter, the following five types have been prescribed (Fig. 37).

B_1 — one-fourth *(caturthi)* square brick—30 × 30 sq. *aṅgulas;* that is, a square whose side AB is $\frac{1}{4}$ *pu.* or 30 *aṅgulas.*

B_2 — half brick *(ardhā)* obtained by cutting the one-fourth square brick diagonally; each of 2 sides AB, AC equals 30 *aṅgulas* and the diagonal side or hypoteneuse BC 30 $\sqrt{2}$ *aṅgulas.*

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[a] *Śat. Br.* X. 2.1.1. (Eggeling's translation).

[b] *Śat. Br* . X. 2.1.4.

B_3 — quarter brick *(pādyā)*, obtained by cutting the one-fourth brick diagonally; each of 2 sides AB, AC equals 15 $\sqrt{2}$ *aṅg.* and the hypoteneuse BC 30 *aṅgulas.*

B_4 — four-sided quarter brick *(caturaśra-pādyā)*, of which CD equals $\frac{15}{2}$ *aṅgulas*, BC 15 *aṅgulas*, AB $22\frac{1}{2}$ *aṅgulas*, AD 15 $\sqrt{2}$ *aṅgulas*. 1 *pada* being 15 *aṅgulas*, the measures are given here in *aṅgulas*. *padasaviśeṣa* means the diagonal of a square of side 1 *pada* or 15 *aṅgulas* or the hypoteneuse of a right-isosceles triangle of side 15 *aṅgulas*. Clearly, such a figure is obtained by joining the rectangle $EBCD$ with the isosceles right triangle AED along the common side ED. Its area is $\frac{15 \times 15}{2} + \frac{15 \times 15}{2}$ sq. *aṅgulas* $= 15 \times 15$ sq. *aṅgulas*, the same as that of the quarter brick B_3.

B_5 — half brick $ABCDE$ obtained by joining 2 B_4s along their common longest side AF; this is also called swan-beaked, *haṃsamukhī*.

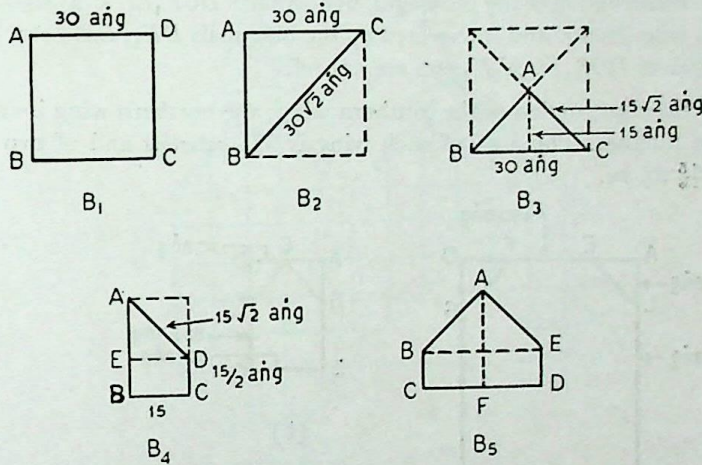



Fig. 37. Brick types.

Areas and Shapes of different parts of the Fire-altar.

10.4-10.9. *The body*: A rectangle $ABCD$ is drawn with AB equal to 2 *pu.* or 240 *aṅg.* and AD 10 *padas* or 150 *aṅg.* (Fig. 38 (a)). FD, DG, HC, CI, BJ, BK, AL and AE are measured out such that each equals 45 *aṅg.* $(=1\frac{1}{2}$ *prakrama*). Join FG, HI, JK and LE. $EFGHIJKL$ is the body of the altar, with its four corners cut off as laid down in the rule. The area is $(240 \times 180 - 2 \times 45 \times 45)$ sq. *aṅgulas* or $\frac{71}{32}$ sq. *pu.* The commentator measures the area in a unit of *ṣoḍaśi* which is 1/16 sq. *pu.* or 30×30 sq. *aṅgulas*, also called a *caturthī*, the area of B_1. In this unit, the area of the body reduces to $35\frac{1}{2}$ *caturthis*,—*evamātmaśronyaṃseṣvardhapañcamāścaturthyo nirastā bhavanti | atha śiṣṭā ardhaṣaṣṭhāstriṃśaccaturthyo bhavanti |*—D.

The head : A rectangle $ABCD$ is formed with AB equal to $82\frac{1}{2}$ *aṅg.* and $BC = 60$ *aṅg.* (Fig. 38 (b)). From the centre E of AD, EF and EG are joined, AE, ED, AG, DF each being equal to 30 *aṅg.* $EGBCF$ is the head measuring $4\frac{1}{2}$ *caturthis* or $\frac{9}{32}$ sq. *pu.* (*itarā ardhapañcamāḥ śiro bhavanti*—D.).

The tail : The tail is formed out of a rectangle $ABCD$, of which AB is 90 *aṅg.* and BC 240 *aṅg.*, by cutting off the two triangles ABE and CDF, where $AB = AE = CD = FD = 90$ *aṅg.* (Fig. 38 (c)). The areas of the tail $EBCF$ is 15 *caturthis* or $\frac{15}{16}$ sq. *pu.*

The wings : A rectangle $ABCD$, of which AB is 150 *aṅg.* and BC 180 *aṅg.*, is formed (Fig. 38 (d)). At the mid-point P of BC a perpendicular PE is drawn towards east so that PE is 90 *aṅg.* Then the triangle EBC is cut off and placed on the eastern side AD as the triangle FAD. The area of the figure $ABECDF$ remains the same as the rectangle $ABCD$. In this way the wing is bent or curved *(nirṇāma)*. That the area is not affected by bending in this way is clearly recognized in the *Śatapatha Brāhmaṇa*: "He then makes the wings crooked, for a bird's wings are crooked.........he thus draws them out by just as much as he draws them in; and thus, indeed, he neither exceeds (its size) nor does he make it too small."[a]

For the construction of the plumages, five squares DGK_1L_1, $L_1K_1K_2L_2$ etc. are drawn with side 30 *aṅg.* and intersected by the diagonals DK_1, L_1K_2 etc. The outer triangular halves DGK_1, $L_1K_1K_2$ etc. are cut off.

This is the construction of the southern wing; the northern wing is constructed in the same manner. The area of each wing is $32\frac{1}{2}$ *caturthis* and of two wings 65 *caturthis* or $\frac{65}{16}$ sq. *pu.*

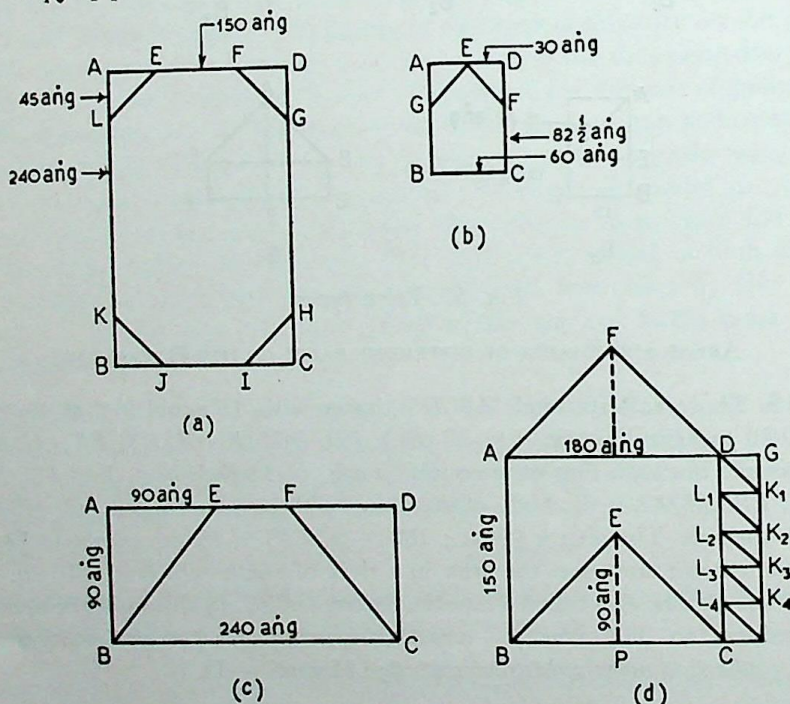



Fig. 38. Different parts of the Falcon with curved wings and extended tail—(a) body, (b) head, (c) tail, and (d) wing with plumages *(patra)*—first type.

[a] *Śat. Br.* X. 2·1.7 ; Eggeling's translation.

The total area of the fire-altar, including the body, the head, the tail and the two wings is ($35\frac{1}{2} + 4\frac{1}{2} + 15 + 65$) or 120 *caturthis* (or *ṣoḍaśis*), that is, $\frac{120}{16} = 7\frac{1}{2}$ sq. *pu.* (*atra ātmani sārdhapañcatriṃśaccaturthyaḥ* / *śirasyardhapañcamāḥ* / *pucche pañcadaśa* / *daśasu patreṣu pañca* / *pakṣayoḥ ṣaṣṭiḥ* / *evaṃ viṃśatyadhikaṃ śataṃ ṣoḍaśyaḥ* / *puruṣakṣetre ṣoḍaśa ṣoḍaśyaḥ śerate* / —D.)

10.10-10.14. *Placement of bricks in the first layer.* The placement of bricks is shown in Fig. 39 (a) and (b). Two methods are given for the head; the second method is shown in (b). In each case the number of bricks employed is 14. At the eastern and the western end of the body near the junctions with the head and the tail 5 B_3s are placed. In the truncated parts, B_2s and B_3s are placed. Since the head has already been covered, this means placement in the 4 corners of the body, 2 sides of the wing (excluding the western end), eastern and western sides of the curved wings and the feathers at the end. The rest is filled with B_1 bricks.

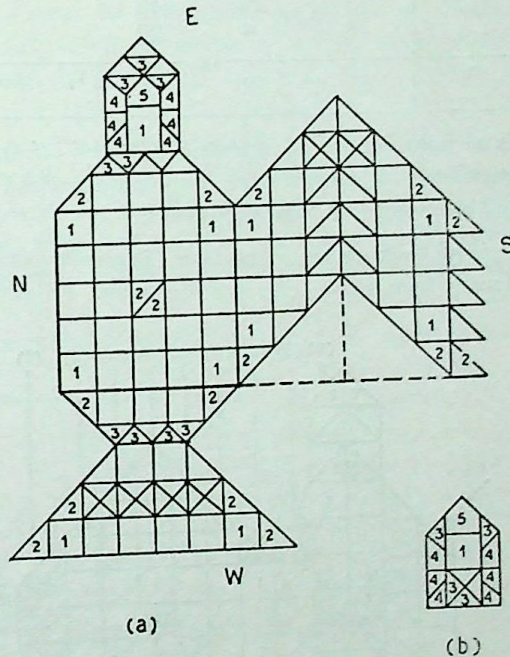



Fig. 39. (a) Arrangement of bricks in the *śyenacit* with curved wings and extended tail (north wing not shown); (b) alternative placement of bricks in the head. First layer.

As pointed out by Thibaut, the bricks specifically mentioned in the *sūtras* 10.10-10.12 total 68; the remaining space, as per *sūtra* 10.13, can be filled with 91 B_1 bricks thus giving a total number of 159 bricks which fall short of 200 bricks[a].

The deficit is to be made good by using B_2s and B_3s as necessary. Dvārakānātha explains that there are 12 rows south-north in the tail and the body excluding the head and the wing (*śirovarjaṃ pucchena sahātmanyudicyo dvādaśa ritayaḥ*). Starting from

[a] Thibaut, 210.

the end of the tail, 4 B_1s in the 2nd row are replaced by 16 B_3s, 2 B_2s in the 3rd row by 4 B_3s and the middle B_1 in the 8th row by 2B_2s. In each wing, excluding the feathers, there are 6 rows west-east. In each of the 3rd and the 4th row from the south, 3 B_1s are replaced by 6 B_2s and 1 B_1 is substituted by 4 B_3s. In the 5th row, 1 B_1 at the bottom is replaced by 2 B_2s. The total number and types of bricks used in the various parts of the fire-altar are shown in Table 5.

TABLE 5. *Number and types of bricks used in different parts of the fire-altar—first layer.*

Parts of the *citi*	Brick type					Total
	B_1	B_2	B_3	B_4	B_5	
Head	1		6	6	1	14
Body	30	6	10			46
Wings	30	62	16			108
Tail	8	4	20			32
Total	69	72	52	6	1	200

D's enumeration is as follows : *evaṃ ṣaṭcatvārimśadātmani | śirasi caturdaśa | dvātriṃśatpucche | pakṣayoraṣṭaśatam | asminprastāre navaṣaṣṭiścaturthyaḥ | ardhā dvāsaptatiḥ pādyā dvipañcāśat | ṣaṭ caturaśrapādyā | ekā haṃsamukhī |*

10.15-10.20. *Placement of bricks in the second layer. Svayamātṛṇṇā* is the central place of the fire-altar. Here it means the centre of the body. To accommodate 4 B_5s, a

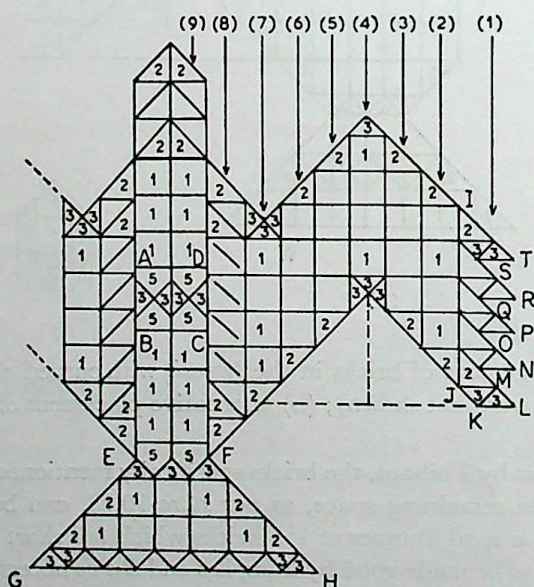



Fig. 40. Arrangement of bricks in the second layer.

rectangle *ABCD* with *AD* equal to 60 *aṅg.* (2 *prakramas*) and *AB* 45 *aṅg.* (3 *padas*) is taken in the centre of the body (Fig. 40). The placement of 4 B_5s and 4 B_3s is shown

as per explanation of the commentator : *svayamātṛṇṇāvakāśamadhyaṃ gṛhītvā padatrayavyāsaṃ prakramadvayadīrghaṃ dīrghacaturaśraṃ dakṣiṇottaraṃ buddhyā parikalpya caturaśrapūrvapārśve pratyagagre dve haṃsamukhyau paścimapārśve prāgagre dve haṃsamukhyau | tāsāṃ madhye dakṣiṇottarāgre antardīrghapārśve pādeṣṭake | caturaśradakṣiṇottarapārśvayormadhyabhūtāntarālayorbahirdīrghapārśve dakṣiṇottarāgre dve pādeṣṭake | evamaṣṭeṣṭakaṃ dīrghacaturaśraṃ bhavati |*

At the junction EF between the tail and the body 2 B_5s and 3 B_3s are placed and at the end of the tail 15 B_3s. The end of the wing containing the plumages, TJKLMNOPQRST, is divided into 5 sections in each of which 1 B_2 and 2 B_3s can be placed. The bricks thus mentioned total 58,—centre of the body 8, junction of the tail with body 5, tail end 15, and plumages at two wings 30.

In the truncated areas, bendings of the wings and junctions (other than already mentioned), B_2s and B_3s are to be placed; as per Fig. 40, these are : B_2—28; B_3—14, total 42. In area, these 100 bricks are equivalent to 36 *caturthis*. Since the total area is 120 *caturthis*, the remaining space can be filled by only 84 B_1s, leaving a deficit of 16 bricks. This is met by replacing 16 B_1s by 32 B_2s. D. proposes to do this in the following manner. In the wings, the body including the head, there are 18 rows west-east starting from the south. In Fig. 40, 9 rows are marked from the south to the central east-west line, there being another such 9 rows in the other half. 6 B_1s in the 8th row between the two extreme B_2s and 2 B_1s west of B_2 in the head in the 9th

TABLE 6. *Number and types of bricks—second layer.*

Parts of the *citi*	Brick types					Total
	B_1	B_2	B_3	B_4	B_5	
Head, including part of body at the junction		10				10
Body, excluding portions accounted for in other parts	12	28	4		4	48
Wings, including part of the body	48	28	34			110
Tail, including part of the body	8	4	18		2	32
Total	68	70	56		6	200

row are replaced by 16 B_2s. Likewise, 8 B_1s in rows 10 and 11 are substituted by 16 B_2s. The final arrangement of bricks in the different parts of the fire-altar is shown in Table 6, in agreement with D's commentary ; *evaṃ pucche dvātriṃśadiṣṭakāḥ | aṣṭapañcāśadātmaśirasoḥ | pakṣayordaśaśatam | asminprastāre'ṣṭaṣaṣṭiścaturthyaḥ | ardheṣṭakāḥ | saptatiḥ | ṣaṭpañcāśatpādeṣṭakāḥ | haṃsamukhyaḥ ṣaṭ |* Note that the number of bricks in the head and the body has not been separately stated.

CHAPTER 11.

CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A FALCON WITH CURVED WINGS AND EXTENDED TAIL—SECOND TYPE

11.2-11.3. *Measurement of the different parts*. We have noticed the use of a new unit of square measure, the *caturthi*, 30 × 30 sq. *aṅgulas* in the case of the *śyenacit* of the first type. Now another unit, the *pañcami*, 24 × 24 sq. *aṅgulas* or 1 sq. *aratni* (a square of side one-fifth of a *puruṣa*) is introduced. Clearly, 7½ sq. *pu.* is equivalent to $\frac{15 \times 120 \times 120}{2 \times 24 \times 24}$ or 187½ *pañcamis*, as stated in the rule 11.2. These units are distributed in the various parts of the fire-altar as follows:

The head	...	3½	*pañcamis* or sq. *aratni*.
The body	...	52	,, ,,
The two wings	...	117	,, ,,
The tail	...	15	,, ,,
Total	...	187½	,, ,,

These given areas must be satisfied in constructing the figures of the various parts as we shall see in the following *sūtras*.

11.4. *Construction of different parts of the falcon*. Unlike the falcon of the first type detailed measurements of the various rectangles involved have not been given. However, with the indications given in the rule and the areas in the previous rules, the various parts can be constructed without difficulty.

The body is made out of a rectangle *ABCD* (Fig. 41(a)), of which $AD=144$ *aṅgulas* or 6 *aratnis*, $AB = 240$ *aṅgulas* or 10 *aratnis* and the area 60 sq. *aratnis*. By the cutting of the corners at distances of 2 *aratnis* (48 *aṅgulas*), 8 sq. *aratnis* are removed so that *EFGHIJKL* measures exactly 52 sq. *aratnis*.

The head is constructed out of a rectangle 48 × 54 sq. *aṅg*. ($AE = AG = ED = DF = 24$ *aṅgulas*) such that *EFCBG* measures 3½ sq. *aratnis*.

The tail is done in the same way as before. Here *AD* equals 8 *aratnis* (192 *aṅgulas*), *AB* 3 *aratnis* (72 *aṅgulas*) and the area 24 sq. *aratnis* (Fig. 41 (c)). *AB, AE, FD, DC* being equal to 3 *aratnis*, 9 sq. *aratnis* are removed, leaving the area of the tail *EBCF* as 15 sq. *aratnis*.

For the wing, the rectangle to be taken should have its side *AD* as 9 *aratnis* (= 216 *aṅgulas*) and *AB* 6 *aratnis* (144 *aṅg*.); the area is 54 sq. *aratnis*. The bending *(nirṇāma)* is made as before, the distance *EP* being 3 *aratnis* (72 *aṅgulas*). For the plumages, 6 rectangles DGK_1L_1, $L_1K_1K_2L_2$ etc. are fitted at the end of the tail,

diagonally intersected and outer halves rejected. Now, each such rectangle is *adhyardhā-pañcami*, that is, 36 × 24 sq. *aṅgulas* or $1\frac{1}{2}$ sq. *aratni*; the area of 6 of them is 9 sq. *aratnis* and that of the 6 plumages *(patra)* after rejection of half is $4\frac{1}{2}$ sq. *aratnis*. The total area of each wing is, therefore, $58\frac{1}{2}$ sq. *aratnis* and that of two wings 117 sq. *aratnis*.

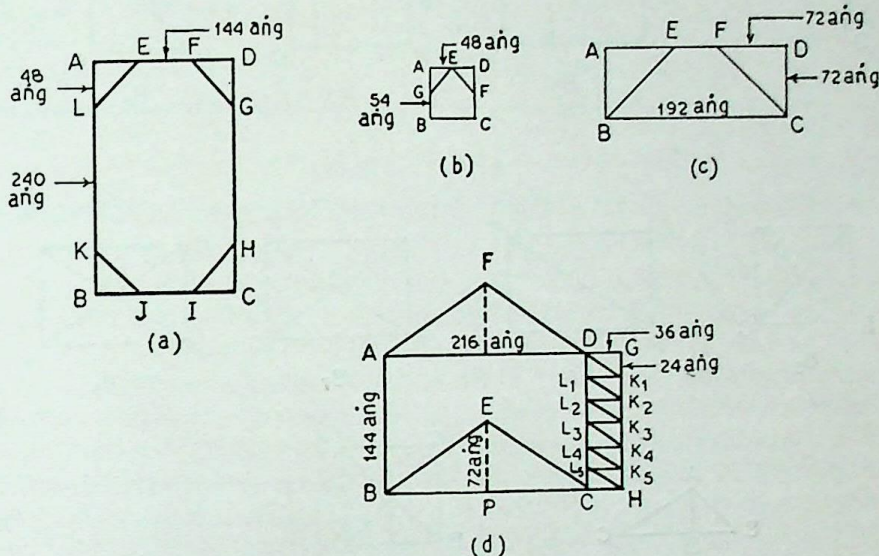



Fig. 41. Different parts of the falcon with curved wings and extended tail : (a) body, (b) head, (c) tail, and (d) wing with plumages—second type.

11.5-11.6. *Type of bricks*. The following ten types of bricks have been prescribed for covering the fire-altar (Fig. 42) :—

B_1 — square brick of side 1/5 *pu*, *pañcami*: 24 × 24 sq. *aṅg.*

B_2 — rectangular brick longer than *pañcami* by half, *adhyardhā-pañcami*: 24 × 36 sq. *aṅg.*

B_3 — rectangular brick longer than *pañcami* by a quarter, *pañcami-sapādā*: 24 × 30 sq. *aṅg.*

B_4 — triangular brick, half of one-fifth, *pañcami-ardhā*: 24, 24, 24 $\sqrt{2}$ *aṅg.*

B_5 — triangular brick, quarter of one-fifth, *pañcami-pādyā*: 24, 12 $\sqrt{2}$, 12 $\sqrt{2}$ *aṅg.*

B_6 — triangular brick, half of *adhyardhā*, *adhyardhārdhā*: 36, 24, 12 $\sqrt{13}$ *aṅg.*

B_7 — triangular brick, quarter of *adhyardhā*, with longer base, $BC = 36$ *aṅg.*, also called *dirghapādyā*.

B_8 — triangular brick, quarter of *adhyardhā*, with a short base, $BC = 24$ *aṅg.*, also called *śūlapādyā* (pointed like a spear).

B_9 — triangular brick obtained by joining one one-eighth of a *pañcamī* brick ABD with one one-eighth of an *adhyardhā* brick ADC along the common side AD (= 12 *aṅg*); also called *ubhayī*.

B_{10} — triangular brick, one-eighth of a *pañcamī*, 12, 12, 12 $\sqrt{2}$ *aṅg*.

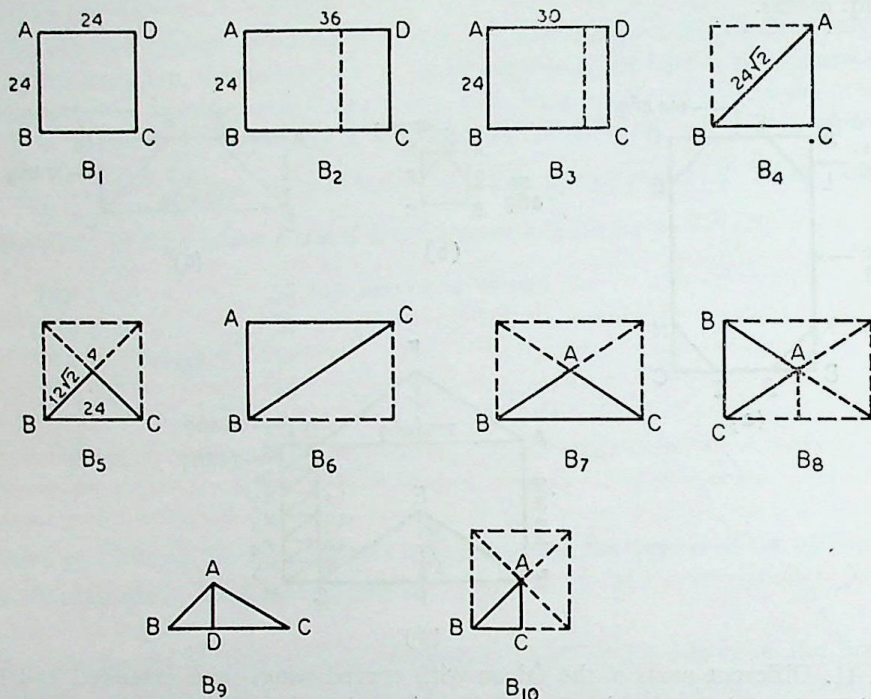



Fig. 42. Brick types.

11.7-11.9. *Placement of bricks in the first layer*. The arrangement of bricks is illustrated in Fig. 43. As the *sūtras* have not given details further than some general directions, D's commentary has been followed to explain the disposition of 200 bricks.

The fire-altar from the western end of the tail, through the body, upto the eastern tip of the head, excluding the wings, is divided into 15 rows south-north. Beginning with the western end as the first layer, the number and types of bricks are as follows :—

1st row, in the tail	— B_1 — 6; B_4 — 2 ;	total	— 8
2nd row, ,,	— B_1 — 4; B_4 — 2 ;	total	— 6
3rd row, ,,	— B_4 — 6 ;	,,	— 6
4th row, in the body	B_4 — 6 ;	,,	— 6
5th row,, .,	— B_1 — 4; B_4 — 2 ;	,,	— 6
6th-11th row ,,	— B_1 — 6 × 6 ;	,,	—36
12th row (like 5th) ,,	— B_1 — 4; B_4 — 2 ;	,,	— 6
13th row (like 4th) ,,	— B_4 — 6 ;	,,	— 6
14th row, in the head —	B_3 — 2 ;	,,	— 2
15th row, ,,	B_4 — 2 ;	,,	— 2
			84

In each wing, there are six rows, west-east plus the 7th row of plumages, of which brick placements in the southern wing are as follows:—

1st row (immediately after the body)	— B_2 — 5 ;	B_6 — 2 ;	Total	— 7
2nd row ,,	— B_2 — 5 ;	B_6 — 2 ;	,,	— 7
3rd row ,,	—	B_6 — 12 ;	,,	—12
4th row ,,	—	B_6 — 12 ;	,,	—12
5th row ,,	— B_2 — 5 ;	B_6 — 2 ;	,,	— 7
6th row ,,	— B_2 — 5 ;	B_6 — 2 ;	,,	— 7
7th row of plumages *(patra)*	—	B_6 — 6 ;	,,	— 6
				58
In the northern wing, the arrangement is same, but reverse			,,	—58
			Total	116

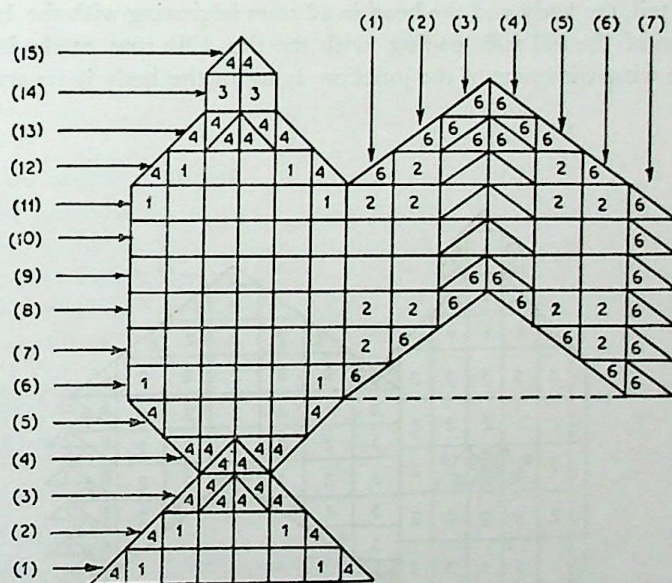



Fig. 43. Arrangement of bricks in the syenacit—second type, first layer.

The number and types of bricks used in the different parts of the altar are shown in Table 7, in agreement with D's enumeration : *ātmani ṣaṣṭiriṣṭakāḥ | viṃśatiḥ pucche | catasraḥ śirasi | pakṣayoḥ ṣoḍaśaśatam | asminprastāre catuḥpañcāśat-pañcamyaḥ | aṣṭāviṃśatirardhāḥ | dve sapāde | catvāriṃśadadhyardhāḥ | ṣaṭsaptatiradhyardhārdhyāḥ |*

TABLE 7. *Number and types of bricks used in different parts of the fire-altar—first layer*

Parts of the *citi*	Brick types					Total
	B_1	B_2	B_3	B_4	B_6	
Head			2	2		4
Body	44			16		60
Wings		40			76	116
Tail	10			10		20
Total	54	40	2	28	76	200

11.10-11.13. *Placement of bricks in the second layer*. By placing B_9 bricks *(ubhayī)* at the eastern and the western end of the junction line between the wing and the body such that 12 *aṅg.* of the base lies in the body and 18 *aṅg.* in the wing, the *sūtrakāra* avoids the overlapping of edges of bricks in the two layers (Fig. 44). This is also the purpose of placing B_9s on each side of the head and B_2s at the end of the tail flanked at the western corners by B_5s and B_{10}s. For the complete arrangement of bricks, we again follow the commentator who this time divides the tail, the body and the head in 12 rows beginning with the 1st row at the western end of the tail and ending with the the 12th row at the head. In this division the wing with part of the junction lying in the body is separately treated as before.

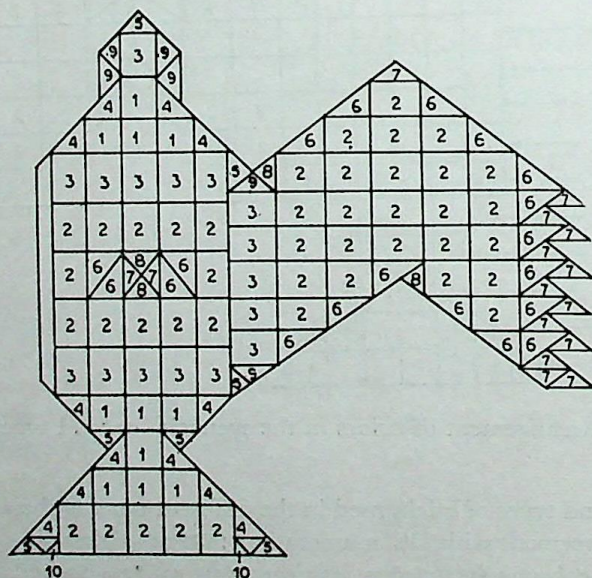



Fig. 44. Arrangement of bricks in the *śyenacit*—second type, second layer.

Row	Bricks	Total
1st row, in the tail (western)	—B_2 — 5 ; B_4 — 2 ; B_5 — 4 ; B_{10} — 2 ;	Total 13
2nd row, ,, (middle)	—B_1 — 3 ; B_4 — 2 ;	,, 5
3rd row, ,, (junction with body, *sandhirītyā*)	—B_1 — 1 ; B_4 — 2 ; B_5 — 2;	,, 5
4th row, in the body	—B_1 — 3 ; B_4 — 2	,, 5
5th row ,,	—B_3 — 5 ;	,, 5
6th row, ,,	—B_2 — 5 ;	,, 5
7th row, ,, (middle)	—B_2 — 2 ; B_6 — 4 ; B_7 — 2 ; B_8 — 2 ;	,, 10
8th row, ,,	—B_2 — 5	,, 5
9th row, ,,	—B_3 — 5 ;	,, 5
10th row, ,,	—B_1 — 3 ; B_4 — 2 ;	,, 5
11th row, ,, (at the junction with the head, *śiropyaya*),	B_1 — 1 ; B_4 — 2 ;	,, 3
12th row, in the head	—B_3 — 1 ; B_5 — 1 ; B_9 — 4 ;	,, 6
		72

In each wing there are six rows, west-east, beginning at the junction layer plus the seventh row of plumages.

Row	Bricks	Total
1st row of the southern wing in the junetion (12 *aṅg*. within body and 18 *aṅg*. in the the wing)	—B_3 — 5 ; B_5 — 2 ; B_8 — 1 ; B_9 — 2 ;	Total 10
2nd row	—B_2 — 5 ; B_6 — 2 ;	,, 7
3rd row	—B_2 — 5 ; B_6 — 2 ;	,, 7
4th row (at the bending, *nirṇāma*)	—B_2 — 5 ; B_6 — 1 ; B_7 — 1 ; B_8 — 1 ;	,, 8
5th row	—B_2 — 5 ; B_6 — 2 ;	,, 7
6th row	—B_2 — 5 ; B_6 — 2 ;	,, 7
7th row of plumages (*patrarītyā*)	—B_6 — 6 ; B_7 — 12 ;	,, 18
		64
In the northern wing, the arrangement is the same, but reverse		,, 64
		Total 128

The number and types of bricks used are shown in Table 8.

TABLE 8. *Arrangement of bricks in different parts of the fire-altar—second layer.*

Parts of the *citi*	Brick type										Total
	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	B_{10}	
Head (including portion of body at junction, 12, 11)	1		1	2	1				4		9
Body (excluding portions at junctions with head, tail and wings, 4-10)	6	12	10	4		4	2	2			40
Wings (including junction with body and *patras*)		50	10		4	30	26	4	4		128
Tail (including junction with body, 1-3)	4	5		6	6					2	23
Total :	11	67	21	12	11	34	28	6	8	2	200

In his commentary, *D.* states 9 bricks in the head, 62 in the body, 21 in the tail and 108 in the wings; that is, he includes in the body 20 bricks at the two junctions of the wings with the body and 2 B_5s at the junction of the tail with the body. In the number of brick types, there is no discrepancy : *asminprastāre ekādaśa pañcamyaḥ | dvādaśa tadardhyāḥ | ekādaśa tatpādyāḥ | dve aṣṭamyau | ekaviṃśatiḥ | ubhayyo'ṣṭau | saptaṣaṣṭiradhyardhāḥ | catustriṃśadardhyāḥ | aṣṭāviṃśatidīrghapādyāḥ | ṣaṭ śūlapādyāḥ |.*

CHAPTER 12

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A KITE (*KAṄKACIT*)

12.1-12.6. The kite-shaped fire-altar *(kaṅkacit)* is constructed in the same manner as the *śyenacit.* The areas and shapes of the body and the tail are the same as those of the second type of the falcon with curved wings and extended tail. The area of the body is, therefore, 52 *pañcamis* or sq. *aratnis* and of the tail 15 *pañcamis.* The measure of the head is given as 5 *pañcamis* and that of the two wings 2 × 57 or 114 *pañcamis.* These areas total 186 *pañcamis* or sq. *aratnis,* leaving a deficit of $1\frac{1}{2}$ *pañcamis,* as the total area of the fire-altar is $187\frac{1}{2}$ *pañcamis* (= $7\frac{1}{2}$ sq. *pu.*) This balance area of $1\frac{1}{2}$ *pañcamis,* which is nothing but 1 *adhyardhāpañcamī* (24 × 36 sq. *ang.*) is utilized in making the feet of the bird. The bending of the wing and the plumages are also slightly different from those of the *śyenacit,* 2nd type. The constructions are shown in Fig. 45.

The head is constructed out of a rectangle 48 × 72 sq. *aṅg.* of which the two eastern corners are cut off by 24 *aṅg.* (Fig. 45 (a)).

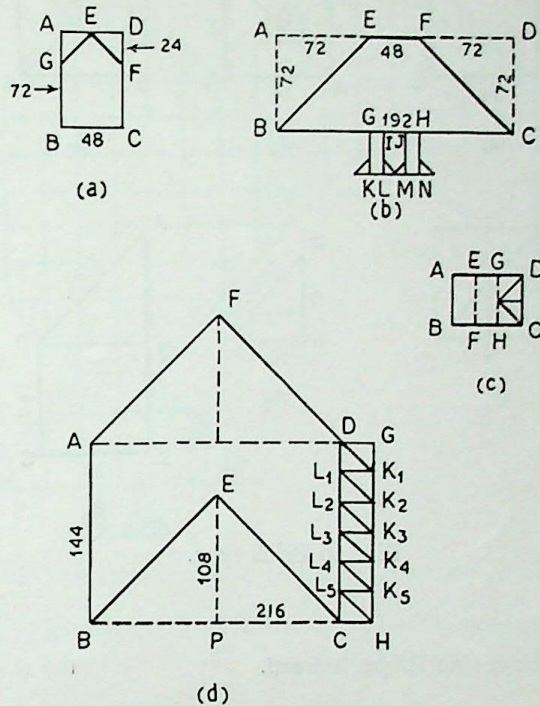



Fig. 45. Parts of the *kaṅkacit* : (a) head, (b) tail, (c) divisions of 1 *adhyardhā-pañcami*, and (d) the wing with plumages.

The construction of the tail *EBCF* is already explained under 11.4. *ABCD* (Fig. 45 (c)) represents the *adhyardhāpañcami* (24 × 36 sq. *aṅg.*), of which the *pañcami* part *ABHG* is halved and used as the two legs *GILK* and *JHNM* (Fig. 45 (b)). The half *pañcami* part *GHCD* (Fig. 45 (c)) is divided into 4 equal triangular parts and used as feet as shown in Fig. 45 (b).

The wing is made of the rectangle *ABCD* (Fig. 45 (d)), of which *AB* = 144 *aṅg.* (6 *aratnis*) and *AD* = 216 *aṅg.* (9 *aratnis*). For the bending, the perpendicular *EP* at the middle of *BC* is 108 *aṅg.* The plumages are constructed out of 6 half *pañcamis* (24 × 24 sq. *aṅg.*) diagonally intersected. Note that the area of each wing is 54 + 3 = 57 *pañcamis*.

12.7. *Types of bricks*. Six types of bricks are prescribed for covering the fire-altar (Fig. 46). These are :

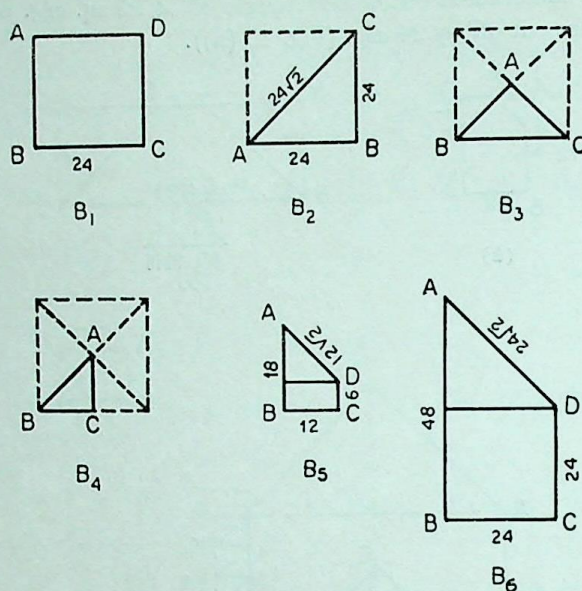



Fig. 46 Brick type.

B_1 — square brick of side 1/5 *pu*, *pañcami*.

B_2 — triangular brick, half of one-fifth, *pañcami-ardhyā*.

B_3 — triangular brick, quarter of one-fifth, *pañcami-pādyā*.

B_4 — triangular brick, one-eighth of one-fifth, *aṣṭami*.

B_5 — four-sided quarter brick of area $\frac{1}{4}$ *pañcami*, *caturaśra-pādyā*. The sides are 6 *aṅg*., 12 *aṅg*., 18 *aṅg*. and 12 $\sqrt{2}$ *aṅg*. (Fig. 46). Its area is 144 sq. *aṅg*. or $\frac{1}{4}$ *pañcami*

B_6 — four-sided brick of area $1\frac{1}{2}$ *pañcami*, *caturaśra-adhyardhā*. The sides are 24 *aṅg*., 24 *aṅg*., 48 *aṅg*., and 24 $\sqrt{2}$ *aṅg*. The area is $(24 \times 24 + 12 \times 24)$ sq. *aṅg*. or $1\frac{1}{2}$ *pañcami* (Fig. 46).

12.8. *Placement of bricks in the two layers*. The rule simply lays down that the two feet of the *kaṅkacit* are to be covered by B_5 and B_4 bricks and the remaining space is to be filled up by such types as these fit. Further details have been avoided as enough indications as to the manner of covering up such bird-like fire-altars with curved wings and extended tail have been given in the foregoing types. Following these indications, Dvārakānātha has proposed an arrangement for filling up the two successive layers, on which basis the Fig. 47 and Fig. 48 are here presented, after Thibaut.

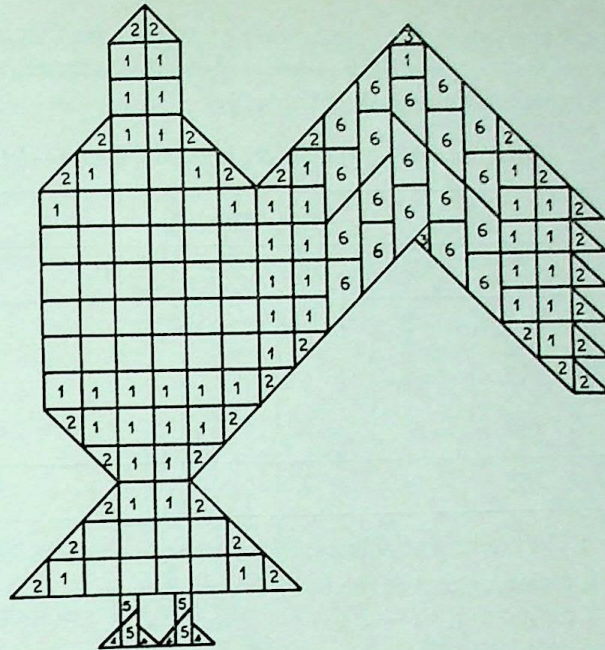



Fig. 47. Arrangement of bricks in the *kaṅkacit*—1st layer.

First layer. The placement of bricks in the first layer is as follows:

(a) In each of two feet — B_5 — 2 ; B_4 — 2 ; total for 2 feet — 8

(b) In the head, at eastern top — B_2 — 2 ;
,, ,, at the remaining space — B_1 — 4 ; total — 6

(c) In the body, at 4 corners diagonally cut — B_2 — 8 ;
,, ,, in the remaining space — B_1 —48 ; total —56

(d) In the tail, along two inclined sides — B_2 — 6 ;
,, ,, in the remaining space — B —12 ; total —18

88

(D. writes : *evamātmaśiraḥ puccheṣu pādābhyāṃ sahāṣṭāśītiriṣṭakāḥ* |)

(e) In the southern wing, at the bending *(nirṇāma)* layer
east-west — B_1 — 1 ; B_3 — 2 ; B_6 — 3 ; total — 6

,, ,, two rows, east-west, on each side of the *nirṇāma* are filled with 4 B_6s per row ; ,, —16

,, ,, In two rows, north and south of the above — B_1 — 20 ; B_2 — 8 ; ,, —28

,, ,, in the plumages — B_2 — 6 ; ,, — 6

56

In the northern wing, the arrangement is the same, but reverse ,, —56

total 112

D. summarizes : *ātmani ṣaṭpañcāśat | pucche'ṣṭādaśa | pādayoraṣṭau | ṣaṭ śirasi | pakṣayord-vādaśaśatam | asminprastāre ṣaḍadhikaṃ śataṃ pañcamyaḥ | catuścatvāriṃśadardhyāḥ | catasraḥ pādyāḥ | aṣṭatriṃśadadhyardhāḥ* | (Table 9).

TABLE 9. *Bricks in different parts of the kaṅkacit fire-altar—1st layer.*

Parts of the *citi*	Brick types						Total
	B_1	B_2	B_3	B_4	B_5	B_6	
Head	4	2					6
Body	48	8					56
Tail	12	6					18
Feet				4	4		8
Wings	42	28	4			38	112
Total	106	44	4	4	4	38	200

Second layer : The placement of bricks in the second layer is as follows :—

(a) In the head, including part of the body at the junction—
B_2 — 2 ; B_3 — 9 ; B_6 — 2 ; total — 13.

(b) In the body, excluding the two junction layers, east-west, with the wings and one junction layer, south-west, with the tail—
B_1 — 35 ; B_2 — 4 ; B_6 — 4 ; total — 43

(c) In the junction layer between the body and the tail—
B_1 — 1 ; B_2 — 2 ; B_3 — 2 ; total — 5

(d) In the tail, excluding the junction layer, there are three layers, south-west, and the arrangement is as follows :—
1st layer in the east — B_2 — 2 ; B_6 — 2 ; total — 4
2nd layer in the middle—B_6 — 4 ; ,, — 4
3rd layer at the end, including feet—
B_3 — 5 on each side with vertices reversed alternately —10
B_2 — part of each lying within each foot — 2
B_3 — 1 ; B_4 — 2, in the middle space of tail — 3
B_4 — 2 ; B_5 — 4, in the remaining space of feet — 6
total —21

About the placement of these 21 bricks, D. comments as follows: *tataḥ pucchāgrarityāṃ pārśvayoḥ pādyāḥ pañca pañca | tato dve ardhye padamadhyagatāgrike prāksthāratnipārśve dakṣiṇottarapārśvasthasaviśeṣe | tayormadhye prāgagrā pādyā | tāmabhitaḥ pratyagagrike dve aṣṭamyau | pādāntayordve dve caturaśrapādye dakṣiṇottarāyate pratyaksthadīrghapārśve | tataḥ pūrvapraviṣṭārdhyāgrasaṃhitāmekaitāmaṣṭamiṃ pāda-madhyayorupadadhyāt | evaṃ samastā ekaviṃśatiriṣṭakāḥ* | A comparison with Fig. 48 will show how exactly and in what detail the placement of each brick has been described by the commentator.

(e) In the junction between the body and the wing—
B_3 — 1 ; B_6 — 4 ; total — 5. Total for two such junctions —10.

(f) In each wing, between the junction layer and the plumages, there are 8 rows, east-west, each with 4 B_6s ; total—32.

(g) In the plumages *(patras)* — B_2 — 6 ; B_3 — 12 ; total—18.

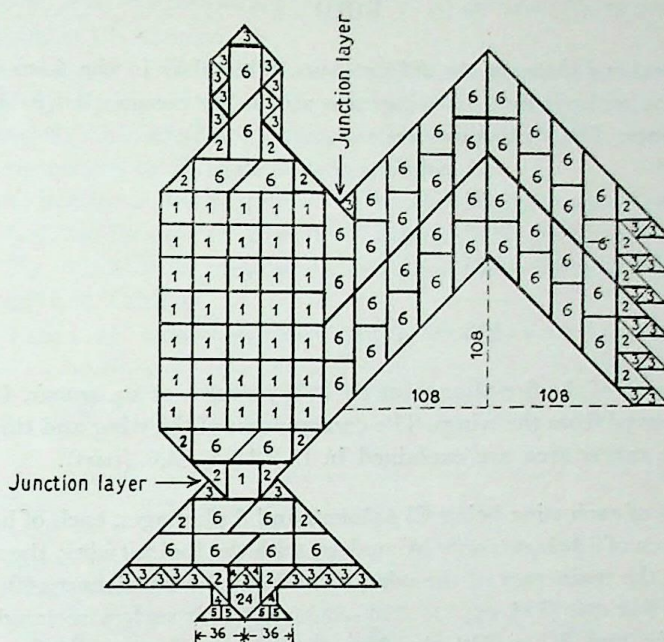



Fig. 48. Arrangement of bricks in the *kaṅkacit*—2nd layer.

The number and types of bricks used in the different parts are summarized in Table 10.

TABLE 10. *Bricks in different parts of the kaṅkacit fire-altar—2nd layer*

Parts of the *citi*	Brick types						Total
	B_1	B_2	B_3	B_4	B_5	B_6	
Head, including part of body		2	9			2	13
Body, excluding junction layers between wings and tail	35	4				4	43[a]
Junction layer between body and tail	1	2	2				5
Tail and feet		4	11	4	4	6	29[b]
Junction layers between body and wings			2			8	10
Wings and plumages, excluding junction layers with body		12	24			64	100
Total	36	24	48	4	4	84	200

[a] D. mentions 56 bricks in the body. This is arrived at by adding 10 bricks of the two junction layers between body and wings and 3 bricks from the junction layer between body and tail. The 2 B_3 bricks *(pādyās)* in the body-wing junction layers properly belong to the wings.

[b] D. mentions 31 bricks. This is obtained by adding 2 B_3s from the junction layer between body and tail.

Chapter 13

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF AN *ALAJA* BIRD

13.1-13.5. *Areas and shapes of the different parts.* This altar in the form of the *alaja* bird should be without feet. Its wings are also to be constructed in a somewhat different manner. The areas given are :

The head—	5	*pañcamis* or sq.	*aratnis.*
The body—	52	,,	,,
The tail —	15	,,	,,
Two wings, 2 × 63 —	126	,,	,,
Total :	198	,,	,,

As the total area of the fire-altar must be $187\frac{1}{2}$ *pañcamis* or sq. *aratnis,* $10\frac{1}{2}$ *pañcamis* are to be removed from the wings. The construction of the wing and the method of removing the excess area are explained in 13.3-13.5, 13.6 (part).

The area of each wing being 63 *pañcamis* and 6 plumages, each of half-*pañcami*, needing an area of 3 *pañcamis* only by analogy with the *kaṅkacit* wing, the rectangular area forming the main part of the wing to be bent should measure 60 *pañcamis* or 6 *aratnis* × 10 *aratnis* (144 *aṅg.* × 240 *aṅg.*). $ABCD$ is such a rectangle of which AB = 144 *aṅg.* and BC = 240 *aṅg.* After bending, it assumes the form $ABECDF$ so that $EP = IF$ = 120 *aṅg.* IE clearly equals 24 *aṅg.* or 1 *aratni*. The *patras* are DK_1L_1, $L_1K_2L_2$ etc. From the geometry it is clear that $I, J, L_5\ H$ lie on the same straight line. Hence the direction (rule 13.4) that, by stretching a cord IH, the area $IECH$ west of the southern half of the wing including the *patras* should be cut off. The

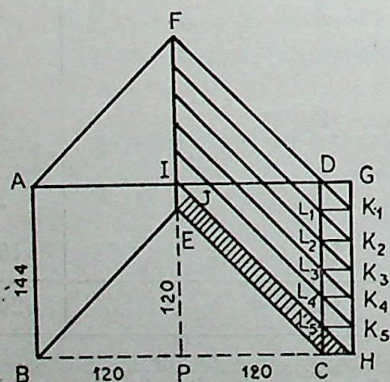



Fig. 49. Wing of the *alaja* fire-altar

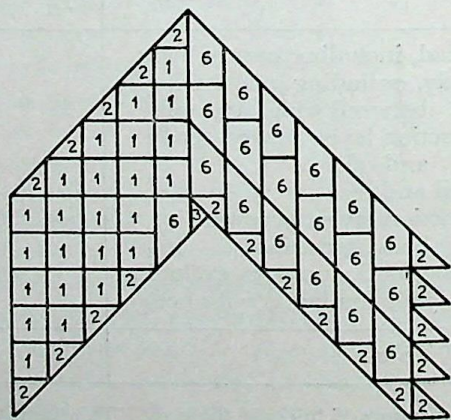



Fig. 50. Arrangement of bricks in the *alaja* fire-altar— 1st layer (southern wing only).

area of the wing south of the *nirṇāma* line EF is 33 *pañcami* and that of $IECH$ $\frac{33}{6}$ or $5\frac{1}{2}$ *pañcami*. The first line of rule 13.6 prescribes that a triangular area EIJ measuring a quarter brick, that is $\frac{1}{4}$ *pañcami* is to be added. In other words, the actual area to be removed is $ECHJ$ measuring $(5\frac{1}{2} - \frac{1}{4})$ or $5\frac{1}{4}$ *pañcami*; for two wings the area to be removed is $10\frac{1}{2}$ *pañcami*.

13.6. *(remaining part). Placement of bricks in the two layers.* For the placement of bricks, only B_1, B_2, B_3 and B_6, as described for the *kaṅkacit*, are required and not B_4 *(aṣṭamī)* and B_5 *(caturaśra-pādyā)*, because the fire-altar is without feet and B_4 and B_5 bricks are needed to cover them.

For the first layer, the placement of bricks in the head, the body and the tail is the same as that for the first layer of the *kaṅkacit*. The arrangement in the wing is shown in Fig. 50, and the number of bricks and their types used in the different parts are given in Table 11.

TABLE 11. *Bricks in different parts of the alaja fire-altar—1st layer.*

Parts of the *citi*	Brick type				Total
	B_1	B_2	B_3	B_6	
Head	4	2			6
Body	48	8			56
Tail	12	6			18
Wings with *patras*	48	38	2	32	120
Total	112	54	2	32	200

D. states : *tatrātmani ṣaṭpañcāśat / śirasi ṣaṭ / pucche aṣṭādaśa / pakṣayorviṃśatiśatam / asminprastāre dvādaśaśataṃ pañcamyaḥ / catuḥpañcāśadardhyāḥ / dve pādye / dvātriṃśadadhyardhāḥ /*

In the second layer, the arrangement of bricks in the head, the body, the two junction layers between the body and the wings and the junction layer between the body and the tail is the same as that of the *kaṅkacit*. In the tail also it is the same except at the end layer owing to the absence of the feet. This end layer is covered by 15 B_3s (Fig. 51).

In each wing (the southern one is here discussed), the arrangement is as follows:

(a) At the layer along the bending *(nirṇāma)*, east-west —
$B_1 = 4$; $B_3 = 1$; $B_6 = 1$; total — 6.

(b) In the 4 layers north of the *nirṇāma*, there are—
4 B_6s in each layer ; total —16.

(c) In the junction layer between wing and body—
$B_3 - 1$; $B_6 = 4$; total — 5.

(d) In the 4 layers south of the *nirṇāma*, each contains
2 B_1s in the middle, 1 B_6 each at east and west end —
$B_1 = 8$; $B_6 - 8$; total — 16.

(e) In the plumages *(patras)*, as in *kaṅkacit*—
$B_2 - 5$; $B_3 - 10$; total — 15.

The total for the southern wing, including the junction layer : 58
The total for the northern wing including the junction layer : 58

116

The arrangement of bricks in the wing and the tail is shown in Fig. 51. Table 12 gives the number and types of bricks used in different parts of the fire-altar.

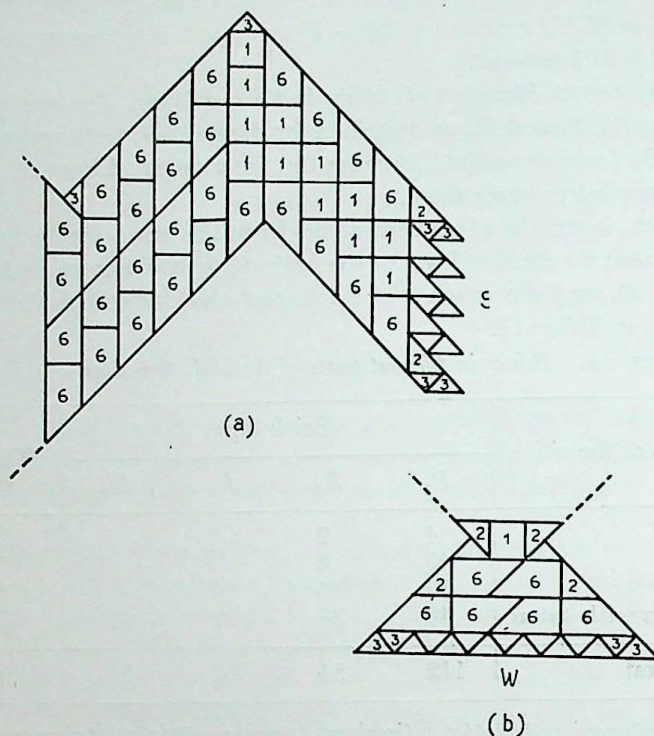



Fig. 51. Arrangement of bricks in the southern wing and the tail, including the junction layers, of an *alaja* fire-altar—2nd layer (other parts not shown); (a) southern wing with junction layer with body, (b) tail with junction layer with body.

TABLE 12. *Bricks in different parts of the alajacit—2nd layer.*

Parts of the *citi*	Brick type				Total
	B_1	B_2	B_3	B_6	
Head, including part of body		2	9	2	13
Body, excluding junction layers with wings	35	4		4	43[a]
Junction layer between body and tail	1	2	2		5
Tail		2	15	6	23[b]
Two wings, including junction layers with body	24	10	24	58	116
Total	60	20	50	70	200

[a] D. mentions 46 bricks which are made up by adding 3 bricks from the junction layer with the tail.
[b] D. mentions 25 bricks which are made up by adding 2 B_3s from the junction layer with the body.

Chapter 14

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF AN ISOSCELES TRIANGLE (*PRAUGACITI*)

14.2. *Measurement of the fire-altar and the types of bricks.* The area of the fire-altar should be $7\frac{1}{2}$ sq. *pu.* Under rule 2.7, Baudhāyana has shown that an isosceles triangle of $7\frac{1}{2}$ sq. *pu.* can be drawn from a square of double this area, that is, 15 sq. *pu.*, by joining the mid-point E of the eastern side AD with two western corner points B and C (Fig. 52). The base BC and each side EB, EC are given by

$$BC = \sqrt{15}\ pu.$$
$$= 120\sqrt{15}\ a\dot{n}g.$$
$$= 464.76 \text{ or } 464\tfrac{3}{4}\ a\dot{n}g. \text{ approx.}$$
$$EB = EC = 300\sqrt{3}\ a\dot{n}g. = 519.6 \text{ or } 519\tfrac{1}{2}\ a\dot{n}g.$$

D. therefore explains that a square with $464\frac{3}{4}$ *aṅg.* ($= 465 - \frac{1}{4}$ *aṅg*) is to be first drawn and the required isosceles triangle constructed, as already stated, in the following terms : *tasyā dvikaraṇi pādonapañcaṣaṣṭicatuḥśatāṅgulā* ($464\frac{3}{4}$ *aṅg*) *dvistāvatyāścaturaśrakṛtāyāḥ pañcadaśapuruṣāyā bhūmeḥ karaṇi / evaṃ caturaśrikṛtāyāḥ pūrvasyāḥ karaṇyā madhyācchroṇi pratyālikhet / tatra karṇarūpayoḥ pramāṇamardhonaviṃśatipañcaśatāṅgulayaḥ* ($519\frac{1}{2}$ *aṅg.*) */ tasya praugasyāparasyāḥ karaṇyāḥ pādonapañcaṣaṣṭicatuḥśatāṅgulāyā...... /*

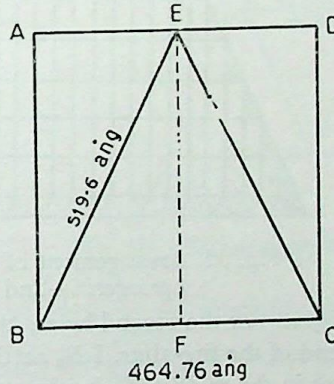
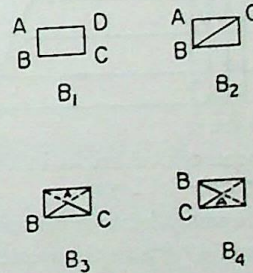



Fig. 52. Fig. 53. Types of bricks.

The following four types of bricks are prescribed (Fig. 53) :

B_1 — a rectangular brick, *bṛhatī*, $\frac{BC}{12} \times \frac{BC}{24}$ or $10\sqrt{15} \times 5\sqrt{15}$ sq. *aṅg.* (38 *aṅg.* 25 *ti* × 19 *aṅg.* $12\frac{1}{2}$ *ti*).

B_2 — a triangular brick half of the *bṛhatī*, diagonally intersected.

B_3 — a triangular quarter brick with long base, *dirghapādyā*.

B_4 — a triangular quarter brick with short-base and pointed like a spear, *śūlapādyā*.

14.3-14.4. *Placement of bricks in the first layer.* All that these two rules say is that half bricks with their hypotenuses turned outside are to be placed on both sides and *bṛhatī* bricks in the remaining space. It is easy to see that 200 bricks cannot be used

to cover the altar in this way. The way it can be done is explained in the commentary.

The *praugaciti* is divided into 24 rows west-east (Fig. 54), 12 on each side of the perpendicular line from the vertex to the middle of the base, and marked 1, 2, 3...... 12. Bricks are placed as follows :—

In the 1st row on each side	— B_2 — 2;	total	2
In the 2nd row on each side	— B_2 — 6;	,,	— 6
In the 3rd-10th row on each side (that is 16 rows)	— B_1 — 88 ; B_2 — 16,	,,	—104
In the 11th row on each side	— B_2 — 42 ;	,,	— 42
In the 12th row on each side	— B_2 — 46 ;	,,	— 46
	Total : B_1 = 88 ; B_2 112 :		200

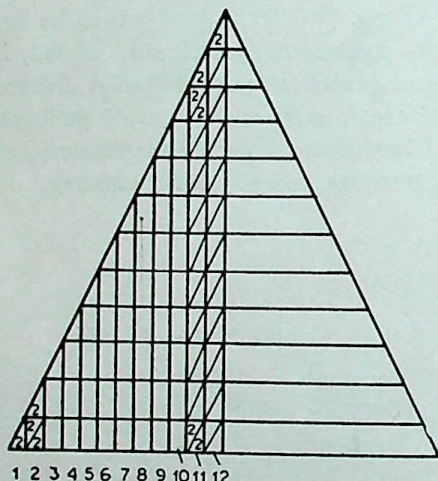



Fig. 54. Arrangement of bricks in the *praugaciti*—1st layer.

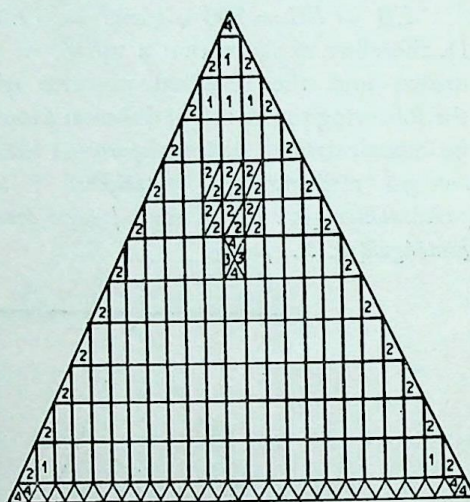



Fig. 55. Arrangement of bricks in the *praugaciti*—2nd layer.

14.5-14.8. *Placement of bricks in the second layer,* For the second layer, the rules direct the placement of 47 B_4s at the western end of the fire-altar, 1 B_4 at the apex, 2 B_3s and 2 B_4s to fill up the *svayamātṛṇṇa* space in the middle, B_2 bricks at the sides and B_1s in the remaining space. The total number of 200 bricks can be completed in the following manner as explained by the commentator (Fig. 55):

(a)	In the apex:	B_4	— 1
(b)	In the western end (base), vertices and bases alternately turned in opposite direction :	B_4	— 47
(c)	In between, there are 11 rows south-north of which sides are filled with B_2s:	B_2	— 22
(d)	In the centre of the middle row — B_3 — 2 ; B_4 — 2 :	total	— 4
(e)	In the 4th and 5th row, 3 B_1s are replaced by 6 B_2s each:	B_2	— 12
(f)	In the remaining space:	B_1	—114
	Total : B_1 — 114 ; B_2 — 34 ; B_3 — 2 ; B_4 — 50		200

(*asminprastāre caturdaśaśataṃ bṛhatyaḥ | catustriṃśadardhyāḥ | pañcāśacchūlapādyāḥ | dve dīrghapādye |* — D.)

CHAPTER 15

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A RHOMBUS *(UBHAYATA PRAUGA)*

15.2. *The construction and the types of bricks.* The method of construction of a rhombus or double isosceles triangle having common base and the two vertices on the opposite sides is given in *Bśl.* 2.8. *ABCD* and *BEFC* are two equal squares, each of area $7\frac{1}{2}$ sq. *pu.* *GBHC* is the desired rhombus of $7\frac{1}{2}$ sq. *pu.* of which *G* and *H* are the mid-points of *AD* and *EF* respectively.

$$BC = 120\sqrt{\tfrac{15}{2}}\ \text{aṅg} = 328.56\ \text{aṅg}.$$
$$BG = GC = BH = HC = 300\sqrt{\tfrac{3}{2}}\ \text{aṅg}. = 367.5\ \text{aṅg}.$$

D. gives the value of *BC* as: *triṇi śatānyaṣṭāviṃśatiścāṅgulaya ardhaviṃśāśca tilāḥ* (.56 *aṅg.* = 19.04 *tila*) *tiryaṅmāni*. Each side of the rhombus is given as : *evaṃ kṛte'-rdhādhikasaptaṣaṣṭiśatatrayamaṅgulayaḥ karaṇyo bhavanti.*

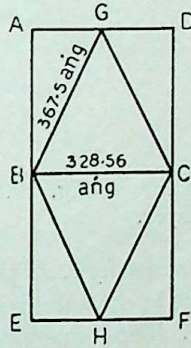



Fig. 56. Measurement of areas and bricks.

Four types of bricks are made in the same way as those for the isosceles fire-altar (14.2). B_1, the rectangular brick, *bṛhatī*, is $\frac{BC}{9} \times \frac{BC}{18}$; bricks B_2 *(ardhyā)*, B_3 *(dīrghapādyā)* and B_4 *(śūlapādyā)* are made by diagonal intersections of the *bṛhatī* as before.

15.3. *Placement of bricks in the first layer. BC* is divided into 18 equal parts and marked and likewise *GH* in 18 equal parts and marked. Lines parallel to *BC* and *GH* are drawn. It is easily seen that the entire area is divided into 144 rectangles where an equal number of *bṛhatī* bricks can be placed and into 36 half rectangles along the sides where an equal number of *ardhyās* can be placed. Thus we get 180 bricks. The deficit is met by replacing 10 B_1s in the 6th vertical row on either side of the central line *GH* by 20 B_2s. With the above substitution, the total number of B_1s is 124 and that of B_2s 76. On these points, the commentary runs as follows : *ṣaṣṭhi dvādaśeṣ-ṭakā /tatra madhyāddaśa bṛhatīrudhṛtya viṃśatirardhyāḥ. . . .asminprastāre caturviṃśatiśataṃ bṛhatyaḥ / ṣaṭsaptatirardhyāḥ /*

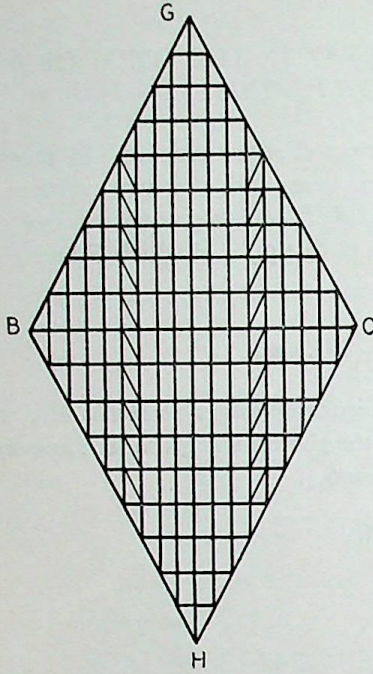



Fig. 57. Arrangement of bricks in the rhombus fire-altar—1st layer.

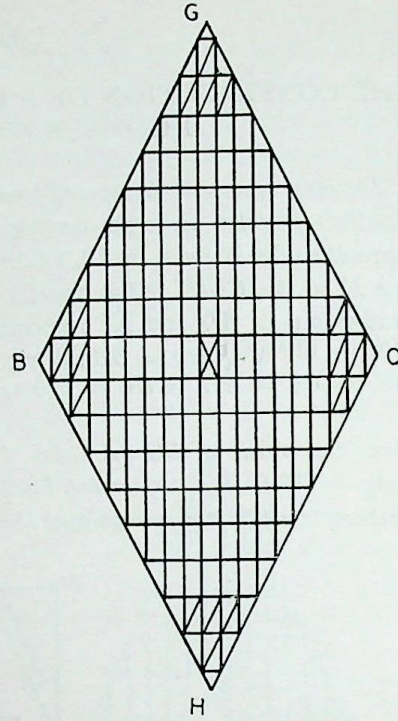



Fig. 58. Arrangement of bricks in the rhombus fire-altar—2nd layer.

15.4-15.6. *Placement of bricks in the second layer*. As per directions in the rules, 2 B_4s (*śūlapādyā*) are to be placed one each at the apices G and H and 2 B_3s (*dīrghapādyā*), one each at B and C (Fig. 58). The remaining space can be divided into 17 horizontal (south-north) and 17 vertical (west-east) rows. In the middle (*svayamātṛṇṇa*) of the fire-altar, 2 B_3s and 2 B_4s are placed as shown. It is easy to see that the remaining space can be filled by 32 B_2s at the sides and 144 B_1s with the longer side turned east or west. This accounts for 184 bricks. The number is completed by replacing 16 B_1s, four each of the four directions, by 32 B_2s. The total number of bricks of different types are : B_1 — 128 ; B_2 — 64 ; B_3 — 4 ; B_4 — 4.

D. comments as follows : *pūrvapaścimacubukayerdve śūlapādye madhye saptadaśodicyo rītayaḥ | sarvatra prāgāyatā iṣṭakāḥ | madhye bṛhatyaḥ | anteṣvardhyāḥ | dakṣiṇottarasrakta-yordīrghapādye | madhyamāyāṃ rītyāṃ madhyamāyāḥ sthāne pūrvavatpādyāḥ | catasṛṣu dikṣu catasraścatasro bṛhatīruddhṛtyāṣṭāvaṣṭāvardhyā nidheyāḥ | evaṃ dviśataḥ prastāraḥ | asminprastāre'ṣṭāviṃśatiśataṃ bṛhatyaḥ | catuḥ ṣaṣṭirardhyāḥ | catasraḥ śūlapādyāḥ | catasro dīrghapādyāḥ |*

Chapter 16

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A CHARIOT WHEEL *(RATHACAKRACITI)*

16.1-16.2. Fire-altars in the form of a chariot-wheel are of two types : (a) a square piece with four circular segments attached one on each side so as to give the whole structure a circular shape, and (b) a circular wheel provided with spokes. Both types are used for sacrificial purposes and are described in this chapter.

The Chariot Wheel with Circular Segments.

16.3. *The construction and brick types.* The method of constructing a circle equivalent to that of a square area, — in this case $7\frac{1}{2}$ sq. *pu.*, has been given in rule 2.9 and has already been discussed. Fig. 59 represents the required circle of area $7\frac{1}{2}$ sq. *pu.*, within which is drawn the largest possible square *ABCD*. The space bounded by each side of the square and the arc of the circle is called *pradhi* (segment) ; there are four such segments.

Let the side of the square *AB* or *AD* be a and the radius of the circle *AO* be r.

$$r = \sqrt{\frac{15 \times 120 \times 120}{2\pi}} \text{ aṅg.}$$

$$= 185.45 \text{ aṅg. or } 185 \text{ aṅg. } 15 \text{ ti.}$$

$$\text{Again, } a^2 = 2r^2 = \frac{2 \times 15 \times 120 \times 120}{2\pi}$$

$$\text{or } a = \sqrt{\frac{15 \times 120 \times 120}{\pi}}$$

$$= 262.27 \text{ or } 262 \text{ aṅg. } 9 \text{ ti.}$$

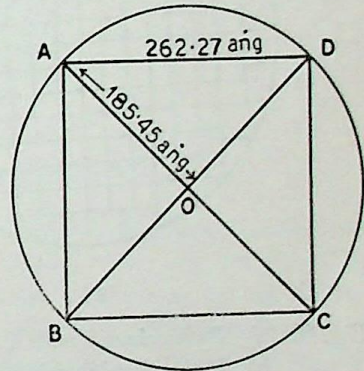



Fig. 59

In the above calculations, π has been taken to be 3.14. D. gives the value of r as 185 *aṅg.* 14 *ti.* *(madhye śaṅkuṃ nihatya pañcāśītiśatāṅgulena caturdaśatilayuktena parimaṇḍala bhramayet)*. His value of a is 262 *aṅg.* 7 *ti* *(tasya madhye viṣkambhārdhadvikaraṇyā* ($r\sqrt{2}$) *saptatilādhikayā dviṣaṣṭiśatadvayāṅgulayā samacaturaśraṃ kuryāt)*. It appears that in giving these values Dvārakānātha used the more approximate correct value of π.

The square bricks are then made with each side equal to the twelfth part of *AD*, which, according to *D*'s value of the side of the inscribed square, is 21 *aṅg.* 29 *ti* (that is, 22 *aṅg* — 5 *ti*).

16.4-16.5. *Placement of bricks.* 144 bricks of the type mentioned above can be placed within the square *ABCD*. In the segments, 6 such bricks are placed adjoining the middle side of the square and the remaining space is divided into 8 parts (Fig. 60 *(a), (b)*). Thus each segment contains 14 bricks and four segments account for 56 bricks, making the total number 200. Regarding the placement of bricks in each segment, D. explains as follows : *pradhimūlamadhye ṣaṭ caturaśrā upadhāya tasya pradheḥ śeṣamaṣṭadhā vibhajet / upahitānāṃ ṣaṇṇāṃ pārśvayordve dve / mukhe catasra iti /*

D. also gives the measurements of these eight bricks as follows (only four will do) :

(1) The corner brick *abg* : *ab* = 33 *aṅg.* — 7 *ti* ; *bg* = 26 *aṅg* + 3 *ti* ;
ag = 42 *aṅg.* — 3 *ti* ;

(2) The 4 sided brick *bchg* : *bc* = 33 *aṅg* — 7 *ti* ; *ch* = 42 *aṅg* + 11 *ti* ;
hg = 36 *aṅg* + 26 *ti* ; *bg* = already given.

(3) The 4 sided brick *deih* : *de* = 33 *aṅg.* — 7 *ti* ; *ei* = 30 *aṅg* — 16 *ti* ;
ih = 34 *aṅg.*; *hd* = $20\frac{1}{2}$ *aṅg.*

(4) The 4 sided brick *efji* : *ef* = 33 *aṅg.* — 7 *ti*; *fj* = $32\frac{1}{2}$ *aṅg.* ;
ji = 33 *aṅg.* — 4 *ti* ; *ei* — already given.

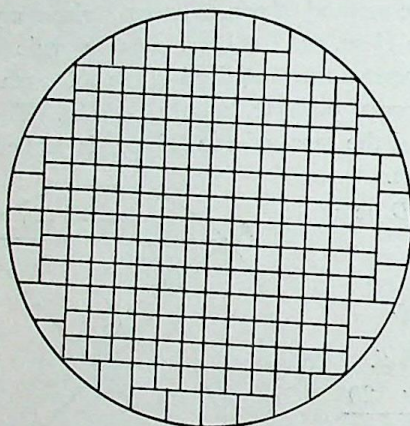
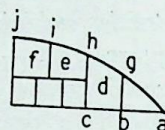



Fig. 60 (a) *Rathacakraciti* with 4 segments— 1st layer (after Bürk, 368).
(b) *Rathacakraciti* with 4 segments—2nd layer (after Bürk, 368).

ag, hg, ih and *ji* are curved. D. neglected the curvature of *ag*, but considered the rest by giving the values of the *śara*, the distance between the centre of the arc and the respective chord in each case. For *hg, ih* and *ji*, these values are 31 *ti;* 26 *ti.*, and 25 *ti.* respectively. Calculation of arcs and their *śaras* were obviously considered important mathematical exercises in medieval India when these commentaries were prepared.

In the second layer the inscribed square is turned such that its corner lies in the centre of each segment of the first layer in order to avoid the overlapping of the edges of the bricks between layers.

The Chariot Wheel with Spokes.

16.6-16.11. *The measurement and the construction of the wheel.* For purposes of measurement of a wheel of this type, square bricks each of area $\frac{1}{30}$ sq. *pu.* are used. The total area of the fire-altar, $\frac{15}{2}$ sq. *pu.* will therefore involve $\frac{15 \times 30}{2}$ or 225 bricks. The side of each brick *a* is given by :

$$a = \sqrt{\frac{120 \times 120}{30}} = \sqrt{480} \text{ } a\dot{n}g. = 21 \text{ } a\dot{n}g. \text{ } 31 \text{ } tila.$$

This agrees with the value given by D. — ......*labdhamekaviṃśatiraṅgulaya ekatriṃśattilāḥ | teneṣṭakāḥ samacaturaśrāḥ kārayet |*

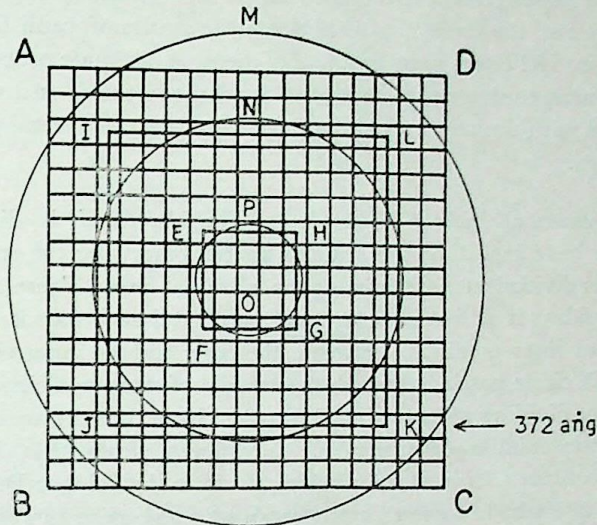



Fig. 61. Construction of the chariot wheel *(rathacakra)* fire-altar.

Now, 225 is a squared number 15^2. A chariot wheel with spokes consists of the central circular part, the nave, the spokes and the outer circular rim, the felly. The spokes connecting the nave and the felly alternate with empty spaces. In the procedure suggested, an area equivalent to the empty spaces between spokes is first added and then removed. This area is here taken to be equivalent to that of 64 square bricks of the type described above, probably because 225 plus 64 make 289, a squared number 17^2. Hence the direction of arranging 289 bricks in the form of a square so that each side contains 17 bricks. This is done in two stages; at first 256 bricks are arranged in a square, each side containing 16 bricks, and then 33 bricks, —17 plus 16, are placed along two adjoining sides. In this way the square *ABCD* is formed (Fig. 61).

In the central region of the above square, another square *EFGH* of 16 bricks is formed. As D. explains, it is constructed out of the central square of 25 bricks by putting 4 poles, one each at the centre of the corner bricks, at *E, F, G* and *H*, and then joining them. The square *EFGH* forms the nave *(nābhi)*.

In the same manner, another square *IJKL* is formed of 144 bricks, centrally placed within *ABCD*. This is again done out of a square of 169 bricks, each side containing 13 bricks. A pole is placed at the centre of each of the four corner bricks, *I, J, K* and *L*, and these poles are joined. The area between the squares *IJKL* and *EFGH* is equivalent to the area of 128 (144-16) bricks, half of which, that is, 64, is used for making the spokes *(arā)* and the remaining half (64 bricks) for the empty spaces *(vedi)*.

The space between the squares *ABCD* and *IJKL*, equivalent to 145 (289-144) bricks constitutes the felly *(nemi)*.

Then three squares *ABCD*, *EFGH* and *IJKL* are turned into circles of radii *OM*, *OP* and *ON* respectively, according to the method given in rule 2.9. The space between the felly and the nave, that is between the circles of radii *ON* and *OP* is radially divided into 32 equal parts and half of them, in alternate order, is removed. In this way, an area equivalent to that of 64 bricks is rejected, and the remaining area of the wheel with the nave, spokes and the felly is exactly equal to that of 225 bricks or $7\frac{1}{2}$ sq. *pu*.

16.12-16.14. *Placement of bricks in the first layer.* The felly *(nemi)* is divided into 64 equal parts. We have seen that the annular space comprising the spokes and the empty spaces was divided into 32 equal parts by radial lines. These are projected into the felly, dividing it at first into 32 equal parts, and each part is then equally divided by radial lines confined between the outer and the inner circumference. Now a concentric circle passing through the middle of these two circumferences of the felly is drawn, dividing its space into 128 parts. Note that the area of each part lying outside the middle circumference is different from that lying within. Accordingly, two types of bricks are required to cover the felly, as D. points out—*bāhyāścatuḥṣaṣṭi / tāsāmekaṃ karaṇam / antataścatuḥṣaṣṭi / tāsāmekaṃ karaṇam /*

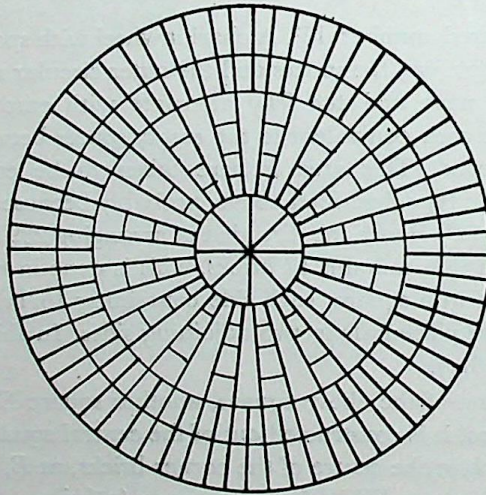



Fig. 62. Arrangement of bricks in the 1st layer (after Thibaut).

Each spoke is divided into 4 parts, thereby involving the use of 64 bricks of four different types. Finally the nave is divided into 8 equal parts to make the total number of bricks in the first layer 200. Thus seven different types of bricks are required to cover the first layer—*evaṃ sapta karaṇāni / eṣa prathamaḥ prastāraḥ / evaṃ śatadvayasampattiḥ /*—D.

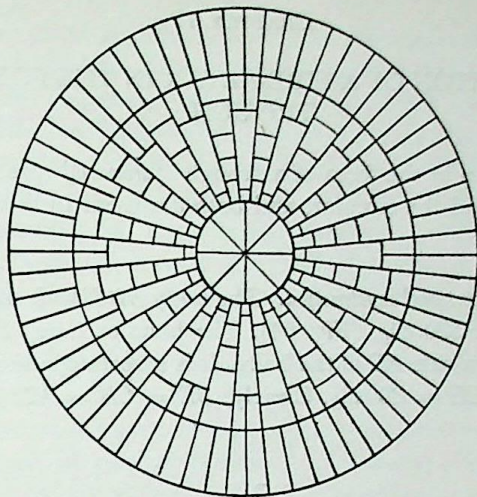



Fig. 63. Arrangement of bricks in the 2nd layer (after Thibaut).

16.15-16-20. *Placement of bricks in the second layer.* The general principle of avoiding overlapping of cleavages of bricks in the two layers is to be kept in view. For this reason, a circle shorter by one-fourth ($\frac{3}{4}$ *OP*) is drawn within the nave; its distance from the edge is therefore a quarter. In the felly, a concentric circle is drawn so that its distance from the inner edge is one-fourth the breadth of the felly *(nemimabhyantarato nemipramāṇacaturthabhāge'tīte parikṛṣet*—D.)

The annular space of the felly between this new circle and the outermost one is divided into 64 equal parts and filled with bricks of one type. Each of the 16 spokes extending from the newly drawn inner circle in the nave upto the newly drawn inner circle of the felly is divided into 5 parts and 5 different types of bricks are used. The spokes will thus involve the use of 80 bricks. In between spokes, in the region of the felly, there are 16 spaces, each of which is divided into two equal parts, and 32 bricks of another type are used to fill them up (*arāṇāmantarāleṣu vedipradeśasamīpe nemyāṃ dve dve iṣṭake / .... tāsāmekaṃ karaṇam / tā dvātriṃśat*—D.). Likewise, there are 16 spaces in the nave between the spokes and outside the inner circle; 16 bricks of another size are used to cover them. The remaining central part of the nave is radially divided into 8 parts and 8 bricks of still another type are employed to cover them. In this way, the total number of 200 (64 + 80 + 32 + 16 + 8) bricks of 9 different types are used. With the 7 types used for the first layer, and 9 for the second 16 different types of bricks are used to construct the fire-altar in the shape of a chariot wheel with spokes.

Chapter 17

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A SQUARE TROUGH

17.1-17.2. Fire-altars in the form of a trough *(droṇacit)* are of two types, e.g., the square shaped and the circular, and both are used. In this chapter, the square type is described.

17.3.-17.5. *Measurement and construction.* The body $ABCD$ of the trough is a square of side $2\frac{2}{3}$ *puruṣas* or 320 *aṅg.* (Fig. 64). The handle *(tsaru)* $EFGH$ is fixed at the middle of the western side BC of the body. It is a rectangle such that $EF = HG =$ 70 *aṅg.* and $FG = EH =$ 80 *aṅg.* Clearly, $BE = CH =$ 120 *aṅg.* The area of the fire-altar is given by

$$\frac{1}{120^2}\left[\ 320^2 + 70 \times 80\ \right] = 7\tfrac{1}{2} \text{ sq. } pu.$$

Fig. 64. Fire-altar in the form of a square trough ; also shows placement of bricks in the first layer.

Fig. 65. Fire-altar in the form of square trough; arrangement of bricks in the second layer.

17.6. *Type of bricks.* The following four types of bricks are used :

B_1	— square bricks of side one-sixth *pu*, *ṣaṣṭhi*	—	20 × 20 sq. *aṅg.*
B_2	— one-sixth brick longer by half, *adhyardhā ṣaṣṭhi*, also called *bṛhatī* here	—	30 × 20 sq. *aṅg.*
B_3	— half bricks, that is, half of *ṣaṣṭhī*	—	20 × 10 sq. *aṅg.*
B_4	— square bricks of side one-fourth *pu*, *caturthī*	—	30 × 30 sq. *aṅg.*

17.7. *Placement of bricks in the first layer.* 6 B_1 bricks are placed on each of *BE* and *HC*, that is, along line between the two western corners and the points where the handle meets the body. The remaining space can be filled with 172 B_2s,—160 in the body and 12 in the handle including part of the body. In this way 12 B_1s and 172 B_2s, totalling 184 bricks, can be placed. The deficit of 16 bricks can be met by using B_3s in place of B_1s *and* B_2s. According to *Dvārakānātha*, 4 B_2s at the end of the handle are replaced by 4 B_1s and 4 B_3s and 12 B_1s along *BE* and *CH* are replaced by 24 B_3s. Now we have 4 B_1s, 168 B_2s and 28 B_3s. (*asmin prastāre catasraḥ ṣaṣṭhyaḥ | aṣṭaṣaṣṭiśatamadhyardhāḥ | aṣṭāviṃśatirardhyāḥ* |—D.)

17.8-17.12. *Placement of bricks in the second layer.* The method of placement is very clearly explained in these *sūtras* and is shown in Fig. 65. After placing 2 B_2s, one on each of the two eastern corners, 13 B_1s can be placed on the eastern side of the body. 10 B_4s are placed on each of the southern and the northern side. The tail contains 9 bricks, — 2 B_1s, 5 B_2s and 2 B_4s. The remaining space in the body can accommodate just 130 B_2s. The total number of bricks thus used is as follows : B_1 — 15 ; B_2 — 137 ; B_4 — 22 ; total — 174. There is a deficit of 26 bricks, which is met by B_3 bricks. According to Dvārakānātha, after replacement of B_2s by B_3s, the number of bricks of different types stands as follows : B_1 — 15 ; B_2 — 124 ; B_3 — 39 ; and B_4 — 22 ; total — 200. Clearly 13 B_2s are replaced by 39 B_3s.

Chapter 18

THE CONSTRUCTION OF FIRE-ALTARS IN THE FORM OF A CIRCULAR TROUGH, AND OF *SAMŪHYA* AND *PARICĀYYA* FIRE-ALTARS

Circular Trough

18.1-18.6. *The construction of the fire-altar.* For purposes of measurements, the *ṣoḍaśī* square bricks of area $\frac{1}{18}$ sq. *pu.* or 900 sq. *aṅg.* (that is, 30 × 30 sq. *aṅg.*) are employed. Clearly, 120 *ṣoḍaśī* bricks equal $\frac{120}{18}$ or $7\frac{1}{2}$ sq. *pu.*, the area of the fire-altar to be constructed. This area equals 108000 sq. *aṅg.* After deducting the area of 1 *ṣoḍaśī* brick of 900 sq. *aṅg.*, the balance of 107, 100 sq. *aṅg.* is converted into a square of which the side obtained by taking the square root works out to 327 *aṅg.* 9 *tila*. Dvārakānātha gives this value as follows : *tasya mūlamāniya navatilasahita-saptaviṃśatyaṅgulasahita-śatatrayāṅgulapramāṇena samacaturaśraṃ kṛtvā* ... |

The next step is to convert the above-mentioned square into a circle by the method given in *sūtra Bśl.* 2.9. and already applied in the case of the fire-altar in the form of the chariot wheel. Let *ABCD* be the square of side equal to 327 *aṅg.* 9 *tila*. (Fig. 66). *EFGH* is the *ṣoḍāśi* brick placed at the middle of the eastern side *AD* of the square. With *O* as centre and *OM* as radius a circle equal in area of the square *ABCD* is drawn, cutting *EFGH* by the curved line(*dhanurvakrā*) *IJ*. The

part of the *ṣoḍaśi* brick *IFGJ* cut by the circle is transferred to the top of the remaining portion, as *KEHL*. Now, *KIJL*, whose area remains the same as that of a *ṣoḍaśi* brick, represents the handle of the circular trough (also called *oṣṭha*).

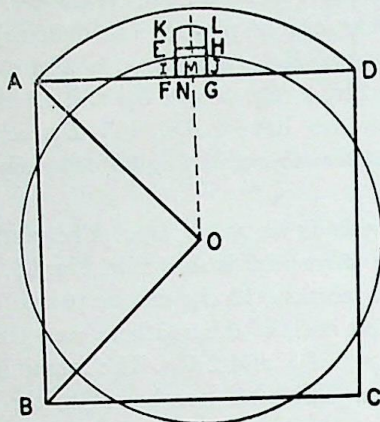



Fig.66. Construction of the circular *droṇacit*.

The value of OM, the radius of the circle can be calculated from the formula $OM = \frac{a}{8}(2 + \sqrt{2})$, where $a = AB = 327$ *aṅg.* 9 *ti.*
Putting $\sqrt{2} = 1.414$, OM works out to 186 *aṅg.* 7 *tila.*
Alternatively, if $AO = r$,
$2r^2 = a^2 = 107100$ sq. *aṅg.*
$r = 231$ *aṅg.* 13 *ti.*

$$MN = \frac{1}{3}\left(r - \frac{a}{2}\right) = \frac{1}{3}\left(231 \text{ aṅg. } 13 \text{ ti} - 163 \text{ aṅg. } 21 \text{ ti}\right)$$

$$= \frac{1}{3}\left(67 \text{ aṅg. } 26 \text{ ti.}\right) = 22 \text{ aṅg. } 20 \text{ ti.}$$

$$OM = 163 \text{ aṅg. } 21 \text{ ti.} + 22 \text{ aṅg. } 20 \text{ ti} = 186 \text{ aṅg. } 7 \text{ ti.}$$

The commentator D. gives the value of OM as 184 *aṅg.* 22 *ti* and that of MN as 21 *aṅg.* 1 *ti.* (*tatra maṇḍalakaraṇe dvāviṃśatitilasahita-caturaśitiśatāṅgulo viṣkambhārdhaḥ | tena maṇḍalakaraṇe viśaya upahitaṣoḍaśimadhye tilasahitaikaviṃśatyaṅgulapramāṇe maṇḍalaṃ pravartate |*) The values given by the commentator are obviously wrong.

18.7-18.9. *Arrangement of bricks in the first layer*. A square *PQRS* as large as possible is inscribed within the circle of the fire-altar as constructed above. The side *PQ* is given by

$$PQ^2 = 2r^2 = \frac{2\pi r^2}{\pi} = \frac{2 \times 107100}{\pi}$$

or $PQ = 261$ *aṅg.* 6 *ti* (*for* $\pi = 3.14$)
The commentator's value is 261 *aṅg.* 4 *ti,* which closely agrees with our value.

Square bricks are made with side equal to $\frac{1}{12}$ *PQ*, that is, 21 *aṅg.* 26 *ti* ($= \frac{1}{12}$ of 261 *aṅg.* 6 *ti*), which is also the value given by the commentator (......*tasya karaṇyā dvādaśena ṣaḍviṃśati tilasahitenaikaviṃśatyaṅgulena pramāṇeneṣṭakāḥ kuryāt*). The inscribed square *PQRS* is filled with 144 such bricks. 6 such bricks are placed in each of the four segments in the middle of, and touching, the square; 24 such bricks are placed in the segments. The remaining space in each segment is divided into 7 parts as shown in Fig. 67 (a), making their number 28. The brick in the centre of the segment in between the row of 6 bricks and the circumference of the circle is 30 *aṅg.* broad and is called *pradhi madhyamā*. With 2 bricks in the handle, as cut by the circle already described, the number of bricks in the first layer totals 198. The deficit is met by replacing 2 corner bricks within the square by 4 half bricks of the one-twelfth type diagonally cut.

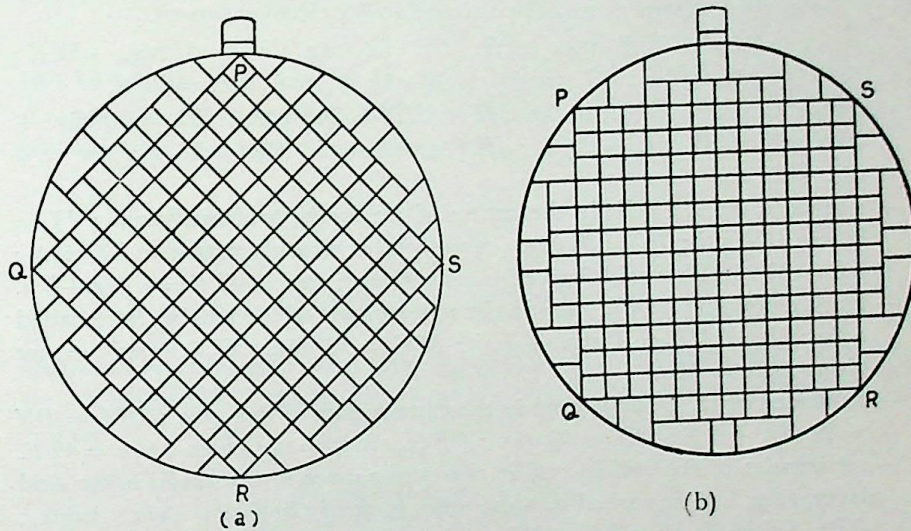



Fig. 67. Arrangement of brirks in the circular *droṇacit*,—(a) first layer; (b) second layer.

18.10-18.11. *Arrangement of bricks in the second layer*. In the second layer, the inscribed square is turned such that the corners point towards intermediate directions Fig. 67(b). The square is filled with 144 one-twelfth bricks as before and 24 similar bricks are placed in the segments. The remaining space in each segment is also divided into 7 parts as in the first layer, making their number 28. To avoid overlapping of edges, the *pradhi madhyamā* brick is placed in the handle, and the space below is equally divided. The total number aggregates to 198. The deficit is met by replacing 2 one-twelfth bricks in the square by 4 half bricks.

Types of bricks. The *sūtras* do not specifically describe the types of bricks. From the descriptions, it is, however, clear that nine types of bricks are used. B_1, B_2, B_3, B_4 and B_5 types are used in each segment; B_6 and B_7 in the handle; B_8 is used in the centre of the segment in one layer; and B_9s are used to complete the number 200. The following particulars of the bricks are based on the commentary (Fig. 68).

B_1 — square brick, $ABCD$, $\frac{1}{12}$ of the side of the inscribed square : side = 21 *aṅg.* 26 *ti.*

B_2 — corner brick, EFG, in the *pradhi* : EF = 33 *aṅg.* — 12 *ti* ; EG = 26 *aṅg* ; FG (curved) = 41 *aṅg* + 25 *ti* ; *śara* = 1 *aṅg.* + 6 *ti.*

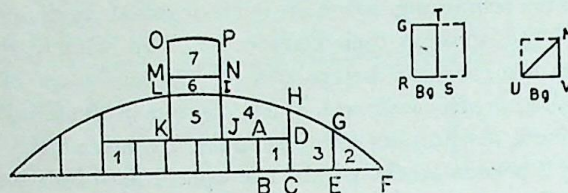



Fig. 68. Different types of bricks used in the circular *dronacit.*

B_3 — four-sided brick $GECH$ in the *pradhi* ; GE = 26 *aṅg.* ; EC = 33 *aṅg.* — 12 *ti* ; CH = 42 *aṅg.* + 8 *ti* ; HG (curved) = 36 *aṅg.* + 16 *ti* ; *śara* = 30 *ti.*

B_4 — four-sided brick, $HDJI$, in the *pradhi* : HD = 20½ *aṅg.* ; JD = 50 *aṅg.* + 10 *ti* ; JI = 31 *aṅg.* + 25 *ti.* ; IH (curved) = 51 *aṅg.* + 18 *ti* ; *śara* = 1 *aṅg.* + 27 *ti.*

B_5 — four-sided brick, $IJKL$, in the centre of the *pradhi, pradhimadhyamā* ; IJ = 31 *aṅg.* + 25 *ti* ; JK = 30 *aṅg.* (commentator wrongly puts it as 32 *aṅg.*) ; KL = 31 *aṅg.* 25 *ti* ; LI (curved) = not given ; *śara* = 42 *ti* = 1 *aṅg.*+8 *ti.*

B_6 — four-sided brick, $INML$, used in the western part of the handle, here called *oṣṭha* ; IN = ML = 9 *aṅg.* — 1 *ti* ; MN = 30 *aṅg.* ; LI (curved) = not given ; *śara* = 42 *ti.*

B_7 — four-sided brick, $OMNP$, used in the eastern part of the *oṣṭha* ; OM = PN = 21 *aṅg.* + 1 *ti* ; MN = 30 *aṅg.* ; OP (curved) = not given ; *śara* = 42 *ti.*

B_8 — rectangular brick, $QRST$, used in the empty space in the *pradhi* in the 2nd layer, after 1 B_5 is pushed into the *oṣṭha*, is clearly half of a *ṣoḍaśi* brick : QR= ST = 30 *aṅg.* ; RS = QT = 15 *aṅg.*

B_9 — triangular brick, UVW, half of B_1 diagonally cut ; UV = VW = 21 *aṅg.* + 26 *ti* ; UW = (21 *aṅg.* + 26 *ti*) $\sqrt{2}$. The commentator incorrectly gives the value of UV = VW as 30 *aṅg.* 15 *ti.*

The Samūhya and the Paricāyya Fire-altar.

18.12-18.15. These *sūtras* deal with *samūhya* and *paricāyya* fire-altars. These altars are circular in shape and constructed in the same manner as the chariot wheel without spokes. The *samūhya* is not covered with bricks, but by loose earth dug out from pits, as stated in the *sūtra.*

The *paricāyya* is, however, covered with bricks in concentric circles. According to Dvārakānātha, 6 equally spaced concentric circles (*agnikṣetre samāntarālāni ṣaṇmaṇḍalāni)* are drawn. The central circle, the *nābhi,* is divided into 8 equal parts. Beginning from the *nābhi,* the second and the third annular spaces are each divided into 16 equal parts ; the fourth annular space is divided into 32 equal parts ; and the fifth and the sixth annular spaces are each divided into 64 equal parts. In this way, 200 bricks are completed for the first layer. There are six different types of

bricks, for the dimensions of radial divisions differ from one annular ring to the other (*pratimaṇḍalaṃ karaṇabhedaḥ | evaṃ ṣaṭ karaṇāni*). In the other layer, concentric circles are drawn in the middle of each annular ring and the inner circle (of the first layer) is removed. Here also we have 6 concentric circles but of different radii. The division of the *nābhi* and the succeeding annular rings is the same as before ; but the radial lines are to be drawn such that these do not coincide with those of the first layer. All these are done to avoid the overlapping of edges. Here also 6 different types of bricks are used.

Chapter 19

THE CONSTRUCTION OF FIRE-ALTARS IN THE FORM OF A PYRE (*ŚMAŚĀNACIT*).

19.1-19.2. The fire-altar in the form of a pyre, as we shall presently see, is a trapezium. For its measurements and constructions as also for the bricks, a new unit has been introduced. Let p be this unit. According to rule 19.2,

$$p^2 = \frac{1}{15} \text{ of the area of the fire-altar} = \frac{1}{15} \times \frac{15}{2} \text{ sq. } pu.$$

$$= \tfrac{1}{2} \text{ sq.} pu.$$

$$p = \frac{1}{\sqrt{2}}\, pu. = \sqrt{7200}\ a\dot{n}g. = 84\ a\dot{n}g.\ 28\ tila.$$

Dvārakānātha explains : *agnikṣetram...pañcadaśadhā vibhajya labdhaṃ saptasahasrāṇi dve śate cāṅgulayaḥ | tasya bhāgasya samacaturaśrakaraṇī ṣaṭtilonapañcāśītyaṅgulā* (85 *aṅg.* —6 *ti.*).

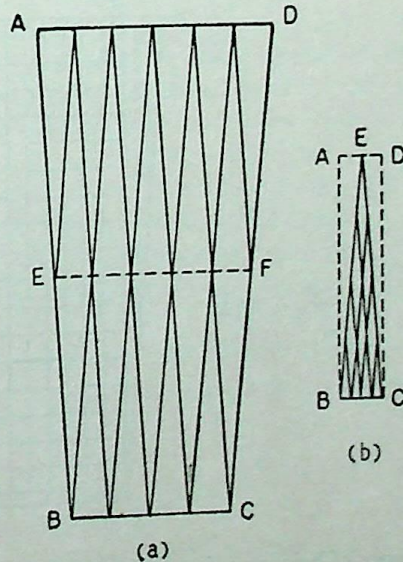



Fig. 69. (a) Fire-altar in the form of a pyre (*śmaśānacit*)—first layer. (b) Method of making isosceles and double isosceles triangular bricks.

The fire-altar is in the form of a trapezium $ABCD$, of which the western side BC is $2p$ units (= 170 *aṅg.* — 12 *tila*), the eastern side AD is $3p$ (= 254 *aṅg.* + 16 *tila*) and the height, that is, the distance between AD and BC is $6p$ (= 509 *aṅg.* — 2 *tila*) (Fig. 69). For the word trapezium, the word *ekato' ṇimaddirghacaturaśra* is used. It means a rectangle of which one side is shorter (than the opposite parallel side). The area of the trapezium is given by

$$2p \times 6p + \frac{p}{2} \times 6p = 15p^2 = \frac{15}{2} \text{ sq. } pu. = 7\tfrac{1}{2} \text{ sq. } pu.$$

which satisfies the area of the *agnikṣetra*.

First layer. For purposes of making the bricks, a rectangle $ABCD$ is formed such that its length AB is $3p$ and breadth BC is $\frac{1}{2}p$. From the mid-point E of AD, join EB, EC. EBC is an isosceles triangle *(prauga)* of area $\frac{3}{4}p^2$. 20 such *praugas* equal $15p^2$ or $7\frac{1}{2}$ sq. *pu.* and can be accommodated within the fire-altar. To attain the number 200, each such isosceles triangle is divided into 10 parts in the manner shown in Fig. 69(b). The sides EB, EC and BC are each divided into 4 equal parts by marking 3 equidistant points on each side. The points on the sides are joined with those on the base as shown, so as to obtain 4 isosceles triangles at the base and 6 double isosceles triangles above them. About the formation of such triangles, the commentator says : *evaṃ vibhakte pṛthvanikasthāḥ praugākārāścatasra iṣṭakāḥ / tatastisra ubhayataḥ praugākṛtayaḥ / tato dve / tata ekā cubukāntā /*

Regarding the placement of 20 isosceles triangles EBC of area $\frac{3}{4}p^2$, a line EF is drawn in the middle of the body (Fig. 69a). In the eastern half, 11 such triangles can be placed, 6 with vertices turned west and 5 with vertices turned east. In

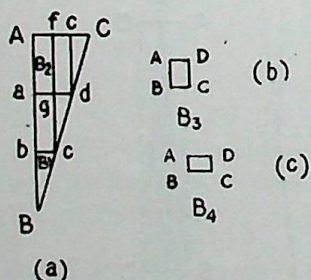



Fig. 70. Types of bricks used in the second layer of the *śmaśānacit*.

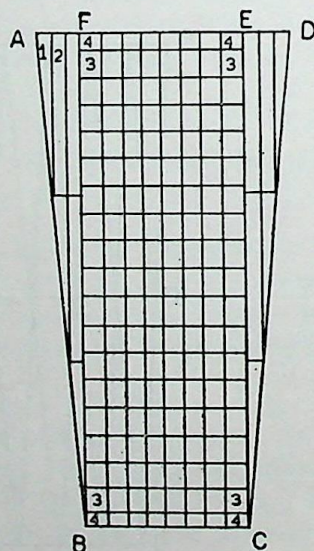



Fig. 71. Arrangement of bricks in the *śmaśānacit* —2nd layer.

the western half, 9 such triangles can be accommodated, 5 with vertices turned west and 4 with vertices turned east. This represents the arrangement of bricks in which 80 *praugas* and 120 *ubhayata praugas* are used.

19.5-19.7. *Bricks and their placement in the second layer.* The entire space of the fire-altar *(agnikṣetra)* can be divided into five large isosceles triangles of base p and height (from vertex to base) $6p$. Three of them have their vertices turned towards west and the vertices of the two in between them are turned towards east. The two isosceles triangles, one on the southern side and the other on the northern, which have their vertices turned towards west, are bisected by perpendicular lines drawn from the vertex to the base (Fig. 71). The *agnikṣetra* is thus divided into three portions, (1) half isosceles triangle CDE on the southern side, (2) the half isosceles triangle BAF on the northern side, and (3) the rectangle $BCEF$ in the middle. Note that, since ED and AF are each $\frac{1}{2}p$, $EF = BC = 2p$.

To make the different types of bricks, the half isosceles triangle on either side is divided into six parts (Fig. 70). AB, BC and AC are divided into three equal parts each by the points, $a, b, c, d, e,$ and f. Join bc, ad, de and cgf. The space is thus divided into 3 half isosceles triangles Bbc, cdg and dce which constitute the first type of brick B_1. Note that $Bb = 2p$, $bc = \frac{p}{6}$. Through the above division, we get the second type B_2, the rectangular bricks $abcg$, $Aagf$ and $fgde$, of which the sides are $2p$ and p . The third type B_3, called the *bṛhati,* is a rectangular brick $ABCD$ (Fig. 70(b)), of which $AB = \frac{1}{3}p$ and $AD = \frac{1}{4}p$. The fourth type B_4 is half *bṛhati* (Fig. 70(c)), a rectangular brick measuring $p/4$ by $p/6$.

The arrangement of bricks in the second layer is shown in Fig. 71. $3B_1$s and 3 B_2s are placed in each of the two half-isosceles parts of the fire-altar. 8 B_4s are placed on the eastern and the western parts each of the rectangular part of the fire-altar, with the longer side turned north-south. (Note that $2p/\frac{1}{4}p = 8$). These two rows use up $\frac{1}{3}p$ and the remaining vertical distance is $(6p-\frac{p}{3}) = \frac{17p}{3}$. The remaining space in the rectangular part of the fire-altar can be divided into 17 horizontal and 8 vertical rows in which 136 B_3 bricks can be fitted with their longer sides turned east. Thus, the number of bricks used in this way totals as follows :

$B_1 — 6$; $B_2 — 6$; $B_3 — 136$; $B_4 — 16$; total — 164.

There is still a deficit of 36 bricks. According to the commentator, the deficit can be met by replacing 36 B_3 bricks (9 from each of the 4 corners) by 72 B_4s. Dvārakānātha says : *pārśvayorupahitapraugārdhayordvādaśeṣṭakāḥ | madhyabhūtacaturaśra (pūrvā) parāntayoḥ ṣoḍaśārdheṣṭakāḥ | madhye ṣaṭtriṃśacchataṃ bṛhatyaḥ prāgāyatāḥ | evaṃ catuḥṣaṣṭi śatamiṣṭakāḥ | ṣaṭtriṃśannyūnā bhavanti | śroṇyaṃseṣu nava nava bṛhatiścaturaśrakṛtā uddhṛtyāṣṭādaśāṣṭādaśārdhyā nidheyāḥ | evaṃ dviśataḥ prastārāḥ |*

19.9-19.11. These *sūtras* deal with the height of the fire-altars and do not call for much comment.

CHAPTER 20

THE CONSTRUCTION OF FIRE-ALTARS IN THE FORM OF A TORTOISE (*KŪRMACIT*)—FIRST TYPE WITH TWISTED LIMBS

20.1-20.2. Fire-altars in the form of a tortoise are of two types, (1) the tortoise with twisted limbs *(vakrāṅgāḥ)* and (2) the tortoise with rounded limbs *(parimaṇḍalāḥ)*. The construction of the first type is described in this chapter.

20.3-20.7. *The construction of the fire-altar.* A square of side 10 *prakamas* or 300 *aṅg* is first constructed and the four corners are cut off by 30 *aṅg* (that is, an isosceles triangle of two equal sides, each 30 aṅg is removed from each corner. $A\ B\ C\ D\ E\ F\ G\ H$ is the shape of the body thus obtained (Fig. 72). Note that $AB = CD = EF = HG = 60\sqrt{2}$ *aṅg.* and $BC = DE = FG = AH = 180$ *aṅg.* Four squares, each of side 30 *aṅg.* are placed side by side in contact with the middle of the eastern side of the body AH. Outer halves of the two side squares are diagonally cut off so as to get the figure $a\ b\ c\ d$. Note that ab equals 60 *aṅg.* Similar figures are constructed in the middle of the other three sides of the body BC, DE and FG.

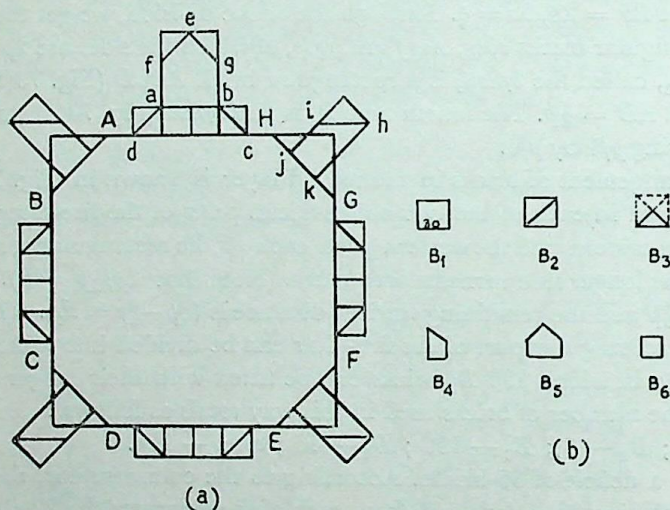



Fig. 72. Fire-altar in the form of a tortoise with twisted limbs.
(a) Lay-out. (b) Brick types.

The head is constructed by placing a rectangle on ab ($ab = 60$ *aṅg*) of which length or height is 75 *aṅg*; the two eastern corners are then cut off by 30 *aṅg* each so as to get the shape *efabg* for the head.

For each foot, a rectangle $30\sqrt{2}$ *aṅg.* broad by $60\sqrt{2}$ *aṅg* long is placed in the middle of the cut off corner, say on HG for the south-east corner. Thereupon, the eastern corner of this rectangle is cut off by $30\sqrt{2}$ *aṅg* so as to obtain *hijk* for the shape of the foot. Similar constructions are made upon EF, CD and AB to build the remaining feet.

The distribution of areas in the different parts of the fire-altar is as follows :
The body *(ātman)* with the four projected areas :

$$\frac{1}{120^2}\left[300^2 - 2 \times 60 \times 60 + 12 \times 30 \times 30\right] = \frac{13}{2} \text{ sq. } pu. \text{ or } 104 \textit{ caturthi.}$$

The head : $\frac{1}{120^2}\left[75 \times 60 - 30 \times 30\right] = \frac{1}{4}$ sq. *pu.* or 4 *caturthis.*

The feet : $\frac{4}{120^2}\left[60 \times 60 - 30 \times 30\right] = \frac{3}{4}$ sq. *pu* or 12 *caturthis.*

The total area $= \left(\frac{13}{2} + \frac{1}{4} + \frac{3}{4}\right)$ sq. $pu = 7\frac{1}{2}$ sq. *pu.* or 120 *caturthis.*

Note that 1 sq. *pu* = 16 *caturthis* or 16 *ṣoḍaśis.* The *caturthi* unit is mentioned here because the commentator has given the measurements in this unit as follows: *ātmani catuḥ śataṃ caturthyaḥ śirasi catasraścaturthyaḥ pādeṣu dvādaśa evaṃ viṃśaśataṃ caturthyaḥ |*

20.8-20.11. *Bricks.* The following 6 types of bricks have been prescribed for covering the fire-altar :—

B_1 — square brick of side 1/4 *pu, caturthi* ; 30 × 30 sq. *aṅg.*

B_2 — triangular brick (diagonally cut), half of *caturthi, ardhyā* ; two sides 30 *aṅg* each, diagonal side $30\sqrt{2}$ *aṅg.*

B_3 — triangular brick, one fourth of *caturthi, pādyā* ; two sides $15\sqrt{2}$ *aṅg* each, the diagonal side 30 *aṅg.*

B_4 — four-sided brick of area $1\frac{1}{2}$ *pādyā* ; its sides are 15 *aṅg.*, 15 *aṅg.*, 30 *aṅg.* and $15\sqrt{2}$ *aṅg.*

B_5 — brick formed by joining 2 B_4 bricks along the longest side, *haṃsamukhī.*

B_6 — square brick of area equal to half *caturthi* ; $15\sqrt{2} \times 15\sqrt{2}$ sq. *aṅg.*

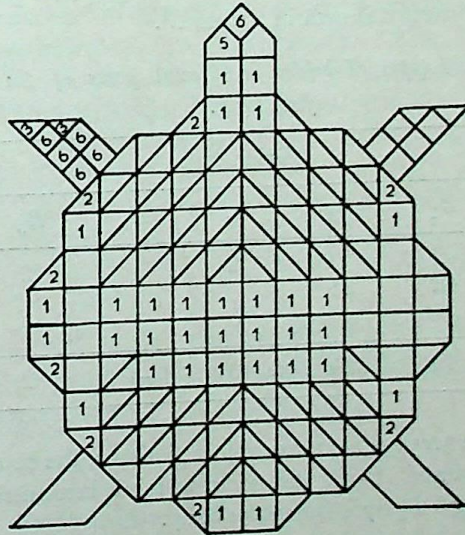



Fig. 73. Fire-altar in the form of a tortoise, showing arrangement of bricks in the first layer.

20.12-20.15. *The placement of bricks in the first layer.* As per *sūtras,* $1B_6$ is to be placed at the tip of the head and below it 2 B_5s (Fig. 73). In each foot 5 B_6s and 2 B_3s are placed as shown in the figure. In the remaining space, B_2s are placed wherever the corners are cut diagonally and B_1s in the rest. Clearly, the number 200 cannot be arrived at in this way; so B_1s are replaced by B_2s as necessary. According to the commentary, this can be done in the following way. Excluding the feet, the whole space of the fire-altar can be divided into 12 vertical rows, — 6 on the southern side of the line passing through the centre of the body and the tip of the head and 6 on its northern side. In the first 6 rows from the southernmost one, the arrangement is as follows :—

1st row : B_1 — 2 ; B_2 — 2 ;	total — 4
2nd row : B_1 — 6 ; B_2 — 2 ;	,, — 8
3rd row : B_1 — 2 ; B_2 — 14 ;	,, —16
4th row : B_1 — 3 ; B_2 — 14 ;	,, —17
5th row : B_1 — 3 ; B_2 — 16 ;	,, —19
6th row : B_1 — 6 ; B_2 — 14 ; B_5 — 1	,, —21
(B_6 at the tip is excluded)	total —85
Likewise, in 6 rows north of the central line;	total —85
In the feet : B_3 — 8 ; B_6 — 20;	total —28
	Total 198

With B_6 at the tip of the head, the total comes to 199. So the commentator observes that to complete the number and for the sake of symmetry B_6 at the tip is replaced by $2B_3$s *(śirasi sūtroktāṃ caturaśreṣṭakāmuddhṛtyāntadirghapārśve pādeṣṭake nidadhyāt |).* The arrangement of bricks is shown in Table 13.

TABLE 13. *Number and types of bricks in different parts of the kūrmacit fire-altar—first layer.*

Parts of the *citi*	Brick type						Total
	B_1	B_2	B_3	B_4	B_5	B_6	
Head	2		2		2		6*
Body	42	124					166*
Feet			8			20	28
Total	44	124	10	—	2	20	200

* After explaining the arrangement, as explained above, the commentator mentions 5 bricks for the head and 167 for the body, which is inconsistent, although it can be done by replacing 1 B_1 by 2 B_2s in the body.

20.16-20.21. *The placement of bricks in the second layer.* In the second layer, 1 B_5 is placed at the tip of the head, flanked on each side by 1 B_3. Below each B_3 on either

side 2 B_4s and 1 B_3 are placed as shown in Fig. 74. In each foot, 2 B_1s and 3 B_2s are placed in such a way that half of 1 B_1 lies in the body to avoid overlapping of

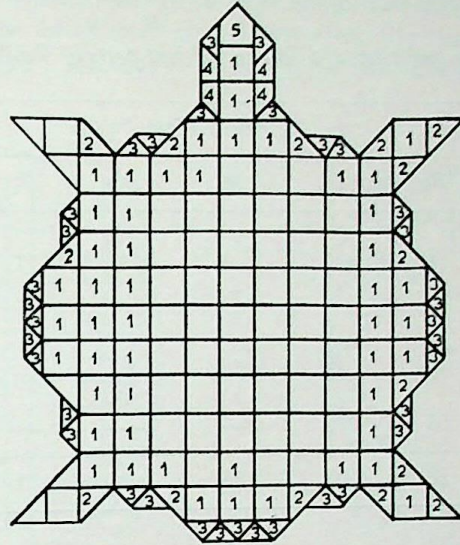



Fig. 74. Fire-altar in the form of a tortoise, showing arrangement of bricks in the second layer.

edges. In the projected part of the body at the centre of each side, 5 B_3s are placed at the end followed by 3 B_1s, part of which lie in the body.

As in the first layer, the second can be divided into 13 vertical rows, excluding part of each foot (containing 4 bricks) as shown in the figure. Starting from the southernmost row, we have :

1st row : $B_3 - 5$;	total	— 5
2nd row : $B_1 - 3$; $B_2 - 2$; $B_3 - 4$	,,	— 9
3rd row : $B_1 - 9$; $B_2 - 2$;	,,	—11
4th row : $B_1 - 9$; $B_3 - 4$;	,,	—13
5th row : $B_1 - 9$; $B_2 - 2$;	,,	—11
6th row : $B_1 - 11$; $B_3 - 4$; $B_4 - 2$	,,	—17
	total	—66
7th (central) row : $B_1 - 13$; $B_3 - 1$; $B_5 - 1$;	,,	—15
The remaining 6 rows on the northern side as in the southern	,,	—66
Remaining parts of 4 feet : $B_1 - 4$; $B_2 - 8$;	,,	—12
	Total	159

Thus there is a deficit of 41 bricks *(ekacatvāriṃśadūnāḥ)*. This deficit is met by replacing 40 B_1s ($5B_1$s from each of the 3rd, 4th, 5th and 6th rows of each of the southern and the northern halves of the *agnikṣetra*) by 80 B_2s. Also 1 B_1 in the head is replaced by 2 B_2s. Dvārakānātha says: *tṛtīyādiṣu catasṛsu pañca pañca caturthiruddhṛtyaṃ catvāri-*

ṃśadardhyā dakṣiṇottarasaviśeṣa upadheyāḥ | evamuttarasminpārśve viparītasaviśeṣāḥ | śiras-yekāṃ caturthīmuddhṛtya dve ardhye upadheye | The final arrangement of bricks in different parts of the fire-altar is shown in Table 14.

TABLE 14. *Number and types of bricks in different parts of the fire-altar—2nd layer.*

Parts of the *citi*	Brick Type						Total
	B_1	B_2	B_3	B_4	B_5	B_6	
Head, including part of body.	1	2	4	4	1	—	12
Body, excluding portions accounted for in head and feet.	49	88	31	—	—	—	168
Feet, including part of body.	8	12	—	—	—	—	20
Total	58	102	35	4	1	—	200

CHAPTER 21

THE CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A TORTOISE—SECOND TYPE WITH ROUNDED LIMBS.

21.2-21-4. *The construction.* Here the method of construction is the same as that already described in the case of the circular trough (chapter 18). We have seen that 120 *ṣoḍaśī* bricks equal $7\frac{1}{2}$ sq. *pu.* 5 *ṣoḍaśī* bricks are taken out and the area of the remaining 115 *ṣoḍaśis* (103500 sq. *aṅg.*) is turned into a square of side 321 *aṅg.* 24 *ti* (the commentator's value is 321 *aṅg.* 25 *ti*). This square is transformed into a circle of the same area as per *Bśl.* 2.9. In this act of circling the square, each of the 5 *ṣoḍaśī* bricks is cut by the circle and the western portion transferred to the eastern side. In this way, each of the 5 *ṣoḍaśī* bricks is rounded off, one of them forms the head and the remaining 4 are attached to the circle in the 4 intermediate directions (Fig. 75).

The next step is to draw within the circle a square of the maximum possible area. The side of the inscribed square, as we have calculated, works out to 256 *aṅg.* 25 *ti.*

21.5-21.9. The side of the inscribed square, 256 *aṅg.* 25 *ti* is divided into 12 equal parts, and squared bricks are formed with side equal to each such part, that is, 21 *aṅg.* 13 *ti* which agrees with the value of the commentator *(trayodaśatilasahitaika-viṃśatyaṅguleneṣṭakāḥ)*. But the commentator's value of 255 *aṅg.* 19 *ti* for the side of the inscribed square is inaccurate inasmuch as it leads to 21 *aṅg.* and 10 *ti* as the side of the square brick and not 21 *aṅg.* 13 *ti* as mentioned.

As in the *droṇacit,* there are four segments. 6 one-twelfth bricks are placed in the middle of the segment in contact with the inscribed square and the remaining space is divided into 7 parts as shown in the Fig. 75. The breadth of the brick in the centre of the segment *(pradhi-madhyamā)* in between the square bricks and the circumference must be 1 *prakrama* or 30 *aṅg.* as in the *droṇacit.*

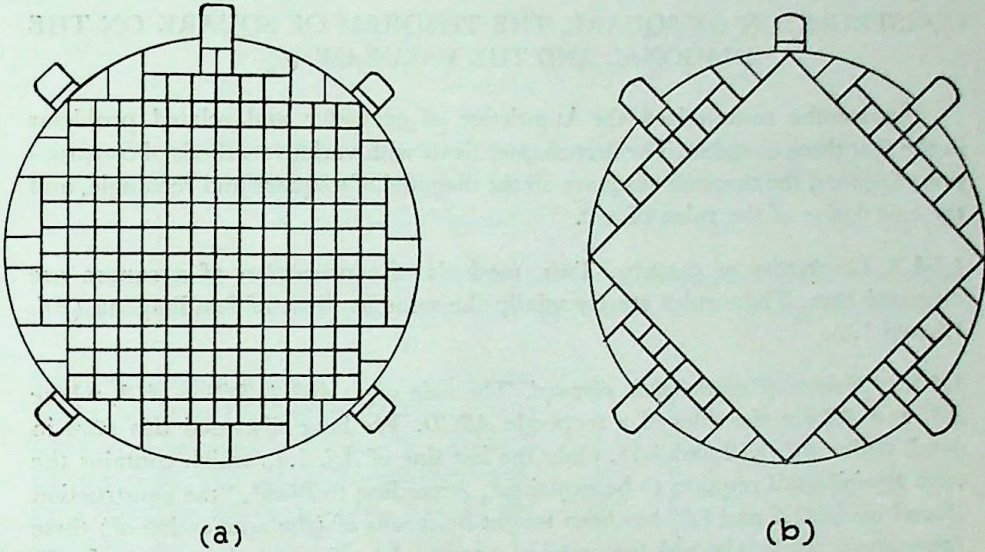



Fig. 75. Arrangement of bricks in the circular *kūrmacit,*—
(a) 1st layer ; (b) 2nd layer.

In the first layer, there are 144 square bricks inside the inscribed square, 24 square bricks in the segments and 28 bricks of different types in the remaining space of the *pradhi*. This makes 196 bricks. Now the *pradhi-madhyamā* is pushed into the head and the vacant space thus created is filled with 2 bricks. The four feet are filled with 8 bricks of two types obtained in the process of cutting the *ṣoḍaśi* square bricks by the circle of the body as referred to before. The total now becomes 206, that is, 6 bricks in excess of the required number of 200. This is adjusted by replacing 18 square bricks by 12 $1\frac{1}{2}$ square bricks. *(aṣṭādaśa caturaśra uddhṛtya dvādaśādhyardheṣṭakā upadadhyāt).*

In the second layer, the inscribed square is turned so that its four corners now point towards east, south, west and north. The placing of the bricks is the same as in the first layer with the difference that the placement of bricks in the feet is as in the case of the head of the first layer and that in the head as in the feet of the first layer. The adjustment is made as before.

The remaining *sūtras* 21.10-21.13 do not call for much comment.

ĀPASTAMBA-SULBASŪTRA

CHAPTER 1

CONSTRUCTION OF SQUARE, THE THEOREM OF SQUARE ON THE DIAGONAL AND THE VALUE OF $\sqrt{2}$

Āpastamba summarized the knowledge of geometry and related problems in the first three chapters. The first chapter deals with various methods of construction of square, the theorem of square on the diagonal of a square and rectangle, and the calculation of the value of $\sqrt{2}$.

1.2-1.3. *Construction of a square.* Two methods of construction of a square are discussed here. These rules are essentially the same as those of Baudhāyana (*Bśl.* 1.8 and 1.5).

1.4-1.5. *Theorem of square on the diagonal.* The rule says, $AB^2 + BC^2 = AC^2$, where AB and BC are the sides of a rectangle $ABCD$. We have discussed this *sūtra* in detail under *Bśl.* 1.12 and 1.13. Only the last line of *Āśl.* 1.4, which contains the term *tābhirjñeyābhi* requires to be explained. According to Bürk[a], "the construction (found in *Āśl.* 1.2 and 1.3) has been taught by means of (the application of) these (*akṣṇayārajju, pārśvamāni* and *tiryaṅmāni* of a rectangle), of course, by means of such as are recognizable (i.e. which can be expressed in recognizable numbers)." *jñā* means 'to know'. Various terms like *jñātumsakti, iti vijñāyate, tābhirjñeyābhi* have been used by the *śulbakāras*. According to Datta [b], these can be interpreted as "known from the ancient scriptures".

The *sūtra* *Āśl.* 2.5, undoubtedly a special case of *Āśl.* 2.4, defines the diagonal of a square a as *dvikaraṇī* or $\sqrt{2}\,a$. This has been discussed in *Bśl.* 1.9-1.11.

1.6. *Value of* $\sqrt{2}$. Extactly the same *sūtra* of Baudhāyana for the value of $\sqrt{2}$ is given here by Āpastamba. This has been discussed under *Bśl.* 2.12.

1.7. *Construction of a square.* This *sūtra* describes another method of construction of a square, not given by Baudhāyana. In Fig. 1, XY represents the given cord. T, U, V are marks at the middle of the cord XY, and of XT and TY respectively. EF is the east-west line. E, M, O, N, F are poles corresponding to X, U, T, V and Y. K represents the sign corresponding to T when the cord XY is stretched after the ends X and Y are fixed at M and N. The mark S corresponding to T is

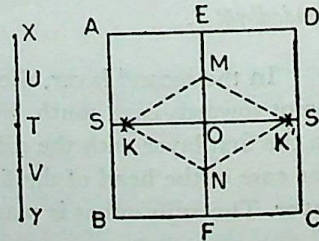



Fig. 1

[a] *Āśl*, **56,** 329.

[b] Datta (2), 128—133.

obtained when both ties at X and Y of the cord are fixed at M and stretched over K. The south-east corner point D is obtained when ties at X and Y are fixed at E and S respectively and stretched by the middle mark T.

Similarly, the other corner points A, B, C are obtained. Hence $ABCD$ is the required square.

CHAPTER 2

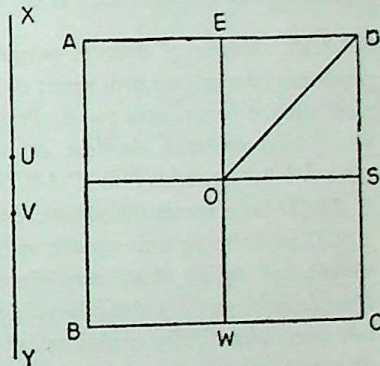
CONSTRUCTION OF SQUARE, SURD, A SQUARE FROM A COMBINATION AND DIFFERENCE OF TWO SQUARES, AND TRANSFORMATION OF A RECTANGLE INTO A SQUARE

This chapter mainly deals with the methods of construction and transformation of geometrical figures like square and rectangle, already dealt by Baudhāyana.

2.1. *Construction of a square.* Āpastamba describes here an interesting method of construction of a square. In Fig. 2, EW represents the east-west line, $2a$; XU the given cord, a; XV the *saviśeṣa* of a, $\sqrt{2}a$; and VY the half cord, a.

Fig. 2

The cord XY is prepared for its use in the construction of the square.

The knots at X and Y are tied at O and E respectively and the cord is stretched by the mark V, which gives the south-east corner D. Then the knot at E is taken off and fixed at W. The cord is likewise stretched by the mark V; which fixes the south-western corner C. The process is repeated in the north-eastern and the north-western side. $ABCD$ is the required construction of the square.

2.2-2.3. *Surd. Dvikaraṇi* means $\sqrt{2}\,a$, where a is the measure; likewise *tṛkaraṇi* is $\sqrt{3}\,a$, and *tṛtīyakaraṇi* $= \frac{1}{\sqrt{3}}\,a$. For details *vide* our discussion under *Bśl.* 1.9-1.11.

2.4-2.6. Āpastamba's methods for making a square out of a combination or difference of two squares are exactly the same as those of Baudhāyana, discussed in *Bśl.* 2.1-2.2. The *sūtra* *Āśl.* 2.6 is an application of the combination of two squares, for instance $a^2 + 3a^2 = 4a^2$, where a is the measure or producer of the square.

2.7. The same method of transformation of a rectangle into a square as given by Baudhāyana in his *Bśl.* 2.5 is discussed.

Chapter 3

TRANSFORMATION OF A SQUARE INTO A RECTANGLE AND A CIRCLE, OF A CIRCLE INTO A SQUARE, AND CONSTRUCTION AS WELL AS ENLARGEMENT OF SQUARES OF DIFFERENT MEASURES FOR SURFACE MEASUREMENTS

The chapter deals with the transformation of squares into rectangles and circles, and of circles into squares. The methods given are the same as those by Baudhāyana. Moreover, Āpastamba has given an idea of surface measures and methods of enlargement or construction of different squares.

3.1-3.2. *Square into a rectangle and circle.* The *sūtra Āśl.* 3.1 describes the method of transformation of a square into a rectangle. This has been discussed in detail under *Bśl.* 2.3-2.4. The methods of transformation from square into a circle given in *Āśl.* 3.2 and *Bśl.* 2.9 are exactly the same; for discussion, *vide Bśl.* 2.9.

3.3. *Circle into a square.* This is the same as that of *Bśl.* 2.10-2.11 (second method).

3.4-3.10. *Squares of different measures and enlargement of areas.* One unit in length produces one square unit area; two units produce four square areas, and three units nine square areas, and so on. *Pramāṇamātreṇa daṇḍena pramāṇamātraṃ kṣetraṃ vidhiyate / dvipramāṇena daṇḍena catvāri pramāṇakṣetrāni bhavanti* (Sundararāja)[a]. The *sūtra Āśl.* 3.7 explains that if $ABCD$ be a square of p units, it produces p^2 unit squares. If $ABCD$ be a rectangle whose length AB has p units and breadth BC q units, then $ABCD$ contains pq unit square areas (Fig. 3). According to Kapardi[b] : *yāvatpramāṇa yāvadāyāmā rajjuḥ tāvato vargānkaroti paṅkti karoti / yāvat saṃkhyā yuktaṃ pramāṇaṃ tāvat saṃkhyāyuktaḥ paṅktiḥ karoti / pañcamānaṃ pañcasaṃkhyā yuktānvargān karoti /* This has been beautifully explained by Karavinda as follows[c] : *dvipramāṇapārśvamānikam-ekapramāṇatiryaṅmāniyakaṃ dvidha' pacchidya dve upalabhyete / dvipramāṇa pārśvamānikaṃ tripramāṇa tiryaṅmānikaṃ prāk dvidhodak tridhā' pacchidya ṣaḍupalabhyante /* This result

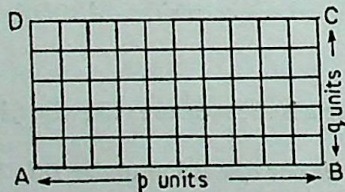
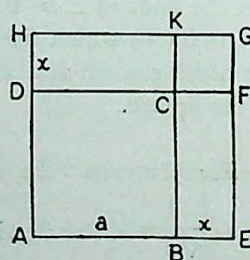



Fig. 3 Fig. 4

was also known to Baudhāyana who used the same method of division of square by parallel lines in connection with the construction of square *gārhapatya* (*Bśl.* 7.4-7.8).

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[a] *Āśl.* Mysore 73, 55, 57.

[b] *Āśl.* Mysore 73, 57.

[c] *Āśl.*, Mysore 73, 58

Depending on the same analogy, *sūtras Āśl.* 3.8. and 3.10 explain that $(1\frac{1}{2}\ a)^2 = 2\frac{1}{4}\ a^2$, and $(2\frac{1}{2}\ a)^2 = 6\frac{1}{4}\ a^2$, $(\frac{1}{2}a)^2 = \frac{1}{4}a^2$, $(\frac{1}{3}a)^2 = \frac{1}{9}a^2$

The method of enlargement of a square of side a by an increment of length x is obtained by $(a + x)^2 = a^2 + 2ax + x^2$, where $ABCD$ is a square of side $AB = a$, and $BE = DH =$ increment x (Fig. 4). For obtaining $(a + x)^2$, two rectangles of area ax are joined at two sides of the original square and a small square of side x is added at the corner. This formula is given by Euclid II.4.

Chapter 4

RELATIVE POSITIONS AND DISTANCES OF GĀRHAPATYA, ĀHAVANĪYA AND DAKṢIṆĀGNI AND CONSTRUCTION OF DĀRŚIKYĀ VEDI

4.1-4.4. Āpastamba has assigned here the relative places of *gārhapatya, āhavanīya* and *dakṣiṇāgni*. Baudhāyana's second method is given by Āpastamba. For detail, *vide Bśl.* 3.1 - 3.5.

4.5-4.6. Āpastamba has followed Baudhāyana's method of construction of *dārśikyā vedi* (vide *Bśl.* 3.6-3.8). The only difference is that Baudhāyana used an isosceles trapezium whereas Āpastamba took a rectangle.

Chapters 5 and 6

THE METHOD OF ONE CORD (*EKARAJJUVIDHI*) AND TWO CORDS (DVIRAJJUVIDHI) AND THEIR USE IN THE CONSTRUCTION OF CERTAIN ALTARS

5.1-5.2. *Construction of mahāvedi by one cord (ekarajjuvidhi).* Āpastamba has described here a method for the construction of the *mahāvedi* (or *saumiki vedi*) with one cord *(ekarajjuvidhi)*[a]. It is an isosceles trapezium, having face 24 *prakramas,* base 30 *prakramas* and height 36 *prakramas,*.

Let XS be the original cord, a, measuring 36 *prakramas*; and SY extra cord, $\frac{a}{2}$, measuring 18 *prakramas.*

U and V are marks on the cord such that,

$$VY = \frac{a}{3} = 12 \text{ prakramas,}$$

$$YU = \frac{5}{12}\ a = 15 \text{ prakramas, and}$$

$$SU = \frac{a}{2} - \frac{5}{12}\ a = \frac{a}{12}$$

[a] Bag, 111—19.

$\therefore\ XU = \frac{13}{12}a$

Now $a^2 + \left(\frac{5}{12}a\right)^2 = \left(\frac{13}{12}a\right)^2$ i.e. $XY^2 + YU^2 = XU^2$

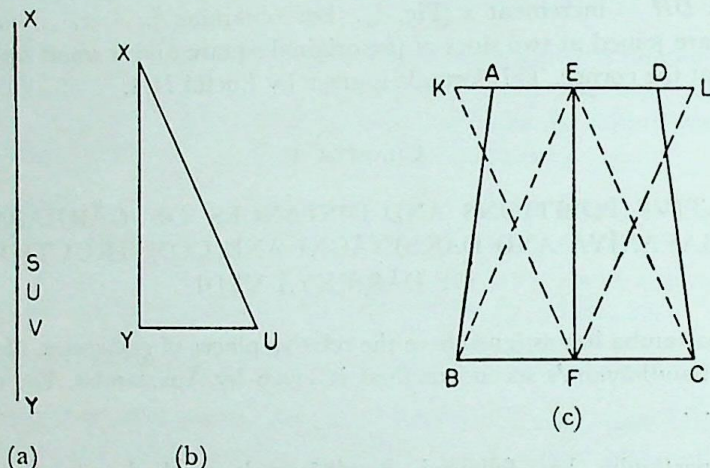



Fig. 5. (a) cord, (b) right-angled triangle made by cord XY, (c) *mahāvedi*.

The cord makes a right-angled triangle XYB. The right-angled triangle has been used for the construction of the isosceles trapezium $ABCD$ where $\triangle^s$ XYU, EFC, EBF, ELF and EKF are equal and $VY = AE = ED$, and $YU = BF = FC$

Here $ABCD$ is the *mahāvedi* (Fig. 5(c)).

5.3-5.5. *Method of two cords (dvirajjuvidhi)*. These rules deal with the construction of an isosceles trapezium with the help of two pieces of cords marked for the construction of right-angled triangles. Here three sets of two-cord relations are given :

First set : From relation $3^2 + 4^2 = 5^2$, the other relations obtained are:

(i) $(3 + 3.3)^2 + (4 + 3.4)^2 = (5 + 3.5)^2$
i.e. $12^2 + 16^2 = 20^2$.

(ii) $(3 + 4.3)^2 + (4 + 4.4)^2 = (5 + 4.5)^2$
i.e. $15^2 + 20^2 = 25^2$.

Second set : The relations are :

(i) $5^2 + 12^2 = 13^2$

(ii) $(5 + 2.5)^2 + (12 + 2.12)^2 = (13 + 2.13)^2$
or $15^2 + 36^2 = 39^2$.

Third set : The relations used are :

(i) $8^2 + 15^2 = 17^2$

(ii) $12^2 + 35^2 = 37^2$

5.7 : *Area of mahāvedi*. The *mahāvedi* covers an area of 972 sq. *padas*. The rule gives hints how to calculate the area by proper transformation. The method is described here. The isosceles trapezium $ABCD$ denoting *mahāvedi* has face, 24, base 30, and

height 36 *padas*. For measuring the area, the portion DCL is cut off and placed in the northern side after inverting it and its new position becomes AKB (Fig. 6).

Now the area $ABCD$ = area $KBLD$

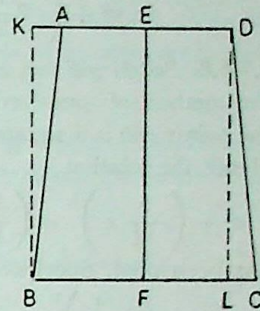
$= EF \times BL$

$= 36 \times 27$

$= 972$ square *padas*.

$[BL = \frac{1}{2}(AD + BC)]$

Fig. 6

It is to be remembered in this connection that the area of the rectangle was already known to Āpastamba (*Āśl.* 3.6 and 3.7). The units of *mahāvedi* are given in *prakramas* and sometimes in *padas*. *padas* are sometimes calculated in terms of *prakramas* (vide *Bśl.* 4.12 - 4.14), though both of them are relative units (*vide* also *Āśl.*6.2).

5.8-5.9. *Sautrāmaniki vedi*. The *sautrāmaniki vedi* is in the form of an isosceles trapezium having face $\frac{24}{\sqrt{3}}$ or $8\sqrt{3}$, base $\frac{30}{\sqrt{3}}$ or $10\sqrt{3}$, and altitude $\frac{36}{\sqrt{3}}$ or $12\sqrt{3}$, and has an area 324 sq. *padas*. For detail, *vide Bśl.* 3.12.

6.1. *Aśvamedha vedi*. Āpastamba has given hints to the construction of similar isosceles trapezium of area 1944 sq. *padas* for the *aśvamedha vedi*. Its area equals $36\sqrt{2} \times \frac{1}{2}(24\sqrt{2} + 30\sqrt{2})$ or 1944 sq. *padas*. This is double of the size of the *mahāvedi*. Hence, for an isosceles trapezium of n times the size of the *mahāvedi*, n being an integer or a fraction, only the unit of measurement of the latter should be replaced by $\sqrt{n}$ times the side of the *mahāvedi*.

6.2. The unit of *prakrama* has been discussed (*Bśl.* 4.12-4.14) and *Āśl.* 5.7). Four officiating priests are usually required for the sacrifice, namely, *adhvaryu*, *hotṛ*, *brāhmaṇa* and the *āgnīdhriya*. The *adhvaryu*[a] should sweep the ground of altars three times and trace out the drawing with the help of the wooden sword.

6.3-6.4. *Nirudapaśubandha vedi by one cord*. The construction of the *nirudapaśubandha vedi* is done according to *ekarajju* measure taught in *Āśl.* 5.1 and 5.2. Here the relation,

$$a^2 + \left(\frac{5}{12}a\right)^2 = \left(\frac{13}{12}a\right)^2, \text{ for } a = 188,$$

$$\text{i.e. } (188)^2 + (78\tfrac{1}{3})^2 = (203\tfrac{2}{3})^2$$

has been used for the construction of isosceles trapezium, whose face in 86 *aṅg.*, base 104 *aṅg.* and altitude 188 *aṅg.*

The construction of another isosceles trapezium having face 3 *aratnis*, base 4 *aratnis*, and altitude 6 *aratnis*, has been obtained by the method of one-cord (*ekarajju-vidhi*). Here the following relation is used :

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[a] *Śrautakoṣa*, I, 213—14.

$$a^2 + \left(\frac{5}{12}a\right)^2 = \left(\frac{13}{12}a\right)^2, \text{ for } a = 6,$$

$$\text{or, } 6^2 + \left(2\frac{1}{2}\right)^2 = \left(6\frac{1}{2}\right)^2$$

6.7-6.8. *Paitṛkī vedi and uttara vedi.* For the construction of the *paitṛki* and *uttara vedi,* the method of one-cord *(ekarajjuvidhi)* has been used. According to Āpastamba, the *paitṛki vedi* is a square of 5 *aratnis,* whereas the *uttara vedi* is a square of 10 *padas.* Hence the relation

$$a^2 + \left(\frac{5}{12}a\right)^2 = \left(\frac{13}{12}a\right)^2, \text{ for } a=5 \text{ and } a = 10$$

has been used. Specifically,

$$5^2 + \left(2\frac{1}{12}\right)^2 = \left(5\frac{5}{12}\right)^2 \text{ [for } paitṛki\ vedi \text{]}$$

$$\text{and, } (10)^2 + \left(4\frac{1}{6}\right)^2 = \left(10\frac{5}{6}\right)^2 \text{ [for } uttara\ vedi \text{]}$$

For further discussion on *paitṛkī vedi, vide Bśl.* 3.11.

6.9-6.11. *Units of measure.* The units like *yuga, pada, śamyā, aratni* and others are relative measures (*vide Bśl.* 1.3).

Chapter 7

CONSTRUCTION OF *SADAS, UPARAVAS, GĀRHAPATYA, DHIṢṆYA* AND *ĀGNIDHRĪYA*

7.1-7.2. *Sada and uparava.* For the construction of rectangular *sada* altar of length 27 *aratnis* and breadth 9 *aratnis,* the method of one-cord *(ekarajjuvidhi)* for $a = 27$ has been used, with the help of the following relation:

$$27^2 + (11\tfrac{1}{4})^2 = (29\tfrac{1}{4})^2$$

The *sada* is also a rectangle of length 18 *aratnis* and breadth 10 *prakramas* (*Bśl.* 4.1 ff) where relation, $18^2 + (7\frac{1}{2})^2 = (19\frac{1}{2})^2$, holds good. For *uparavas, vide Bśl.* 4.1.-4.2.

7.3-7.6. *Gārhapatya vedi.* Āpastamba has considered the construction of both square and circular *gārhapatya vedi* and given methods agreeing with those of Baudhāyana. For details, *vide Bśl.* 7.4-7.8.

7.7-7.8. *Dhiṣṇya and āgnīdhriya.* Details on *dhiṣṇya* and *āgnīdhriya* agree with those given in *Bśl.* 7.9.

Chapters 8 and 9

CHARACTERISTICS OF *AGNI*, GENERAL LAY-OUT AND CONSTRUCTION OF *CATURAŚRAŚYENACIT*, ENLARGEMENT OF UNITS, HEIGHT OF *VEDIS* AND BRICKS

8.1-8.5. The characteristics of *agni* have been discussed under *Bśl.* 5.7-7.3. The general lay-out of the *caturaśraśyenacit* is given in *Āśl.* 8.2; the *ātmā* that is, the body of the

fire-altar measures four sq. *puruṣas*, either wing and tail is each of one sq. *puruṣa*, together with an increment of 24 *aṅg.* in length for the wings and 12 *aṅg.* for the tail. This has already been discussed in *Bśl.* 8.10. For the construction of a fire-altar of $8\frac{1}{2}$ or more sq. *puruṣas*, Āpastamba has followed the same rule as given by Baudhāyana (vide *Bśl.* 5.1-5.6) for proportionate increment of square *puruṣas* from the *agni* of $7\frac{1}{2}$ sq. *puruṣas*.

9.1-9.5. *Construction of square.* Here two methods of drawing a square required for the construction of the body *(ātmā)* of *caturaśraśyenacit* are described. The first method is explained in Fig. 7.

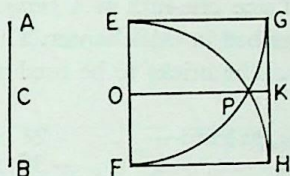



Fig. 7

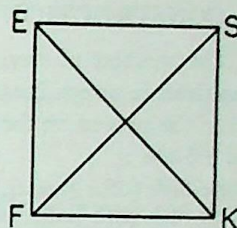



Fig. 8

A, B — holes at the end of a bamboo rod taken equal to the height of a sacrificer with uplifted arms;

C — another hole at the middle of *AB*;

EF — the east-west line, *AB* ;

O — the pole corresponding to the hole *C* of *AB* ;

FG, EH— arcs drawn by the end *B* when *A* is fixed once at *E* and then at *F* respectively ;

P — the point of intersection of the arcs *FG* and *EH* ;

K — the point reached by the hole *B* when *A* is fixed at *O* and *AB* is laid over *OP* ;

G, H — points fixed by *A* and *B* when *C* is fixed at *K*.

Hence *EFGH* is the required construction of the square.

The second method is explained in Fig. 8.

FS — the bamboo rod which is qual to $\sqrt{2}\, a$ (*dvikaraṇi* of the square), where *a* equals one *puruṣa* ;

ES — the bamboo rod of length one *puruṣa* is stretched along the east side ;

S — the common point denoting *aṃsa*, which is one of the corner points of the figure.

Similarly the *śroṇi* point *K* is fixed. *EFKS* is the required construction. Four such squares each of 1 sq. *puruṣa* form the body *(ātmā)* of the *caturaśraśyenacit*.

How any increment to the area of more than 7 fold *agni* is to be effected has already been discussed in *Bśl.* 5.1-5.6.

9.6. *Bricks of caturaśraśyenacit.* Five kinds of bricks used for the *caturaśraśyenacit* are described as follows :

pañcamī, square bricks of side one-fifth of a *puruṣa*, 24 *aṅg.* × 24 *aṅg.* ;
adhyardhā, rectangular brick, 36 *aṅg.* × 24 *aṅg.* ;
ardhyā, a rectangular half of *pañcamī*, 24 *aṅg.* × 12 *aṅg.* ;
caturbhāgiyā, a square brick one fourth of *pañcamī*, 12 *aṅg.* × 12 *aṅg.*
pañcadaśabhāgiyā, a square brick of side one-fifteenth of a *puruṣa* 8 *aṅg.* × 8 *aṅg.*

The heights of bricks in most cases are the same with the exception of the *nākasada* and *pañcacoḍā* bricks, which have the height of the normal bricks used for altar construction. The *pañcacoḍā* and *nākasada* bricks are usually used at the top (*vide Bśl.* 5.7-7.3).

CHAPTER 10

CONSTRUCTION OF A RECTILINEAR *ŚYENACIT*

10.1-10.3. The method of arranging bricks of size one-fifth of a *puruṣa* and those derived from them in a rectilinear *śyenacit* is described in this chapter. The first three *sūtras* indicate the procedure for the first layer. The bricks to be used and already described in 9.6 are :

B_1 — one-fifth (of a *puruṣa*), *pañcamabhāgiya, pañcamī*—	24 × 24 *aṅg*²	
B_2 — one-fifth with half, *adhyardhā-pañcamī*	— 36 × 24	,,
B_3 — half of one-fifth, *ardhā* of *pañcamī*	— 24 × 12	,,
B_4 — quarter of one-fifth, *prādeśa*	— 12 × 12	,,
B_5 — one-fifteenth, *pañcadaśabhāgiyā*, one-ninth of *pañcamī*	— 8 × 8	,,

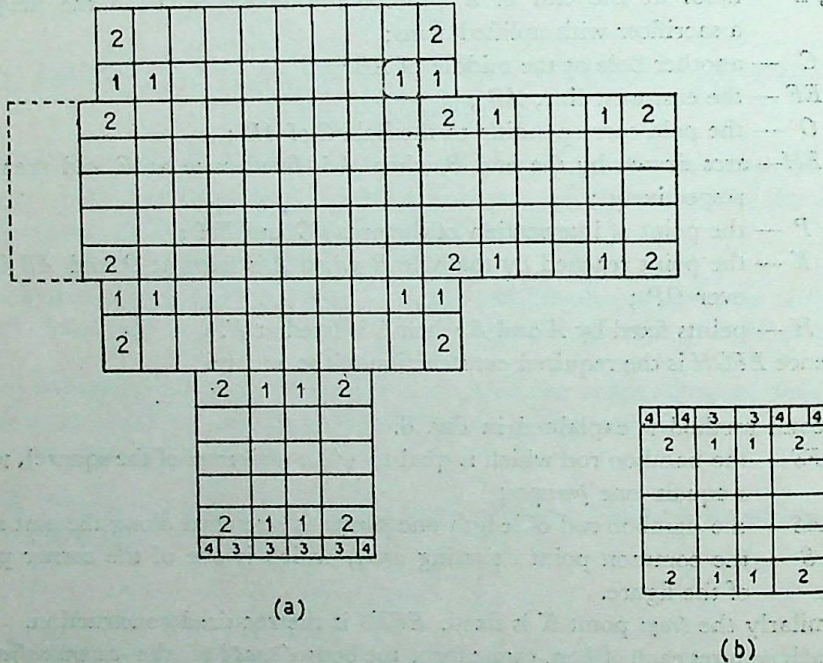



Fig. 9(a) Arrangement of bricks in the first layer of a *caturaśraśyenacit*, in which northern wing is not fully drawn, numbers indicating suffixes used after brick-types;
(b) alternative arrangement in the tail in which the *prādeśakṣetra* is shown nearest to the body.

The arrangement of bricks is shown in Fig. 9 The *adhyardā-pañcami* (B_2) bricks at each juncture of the wing with the body are placed such that 24 *aṅgulas* lie within the body and 12 *aṅgulas* in the wing, as explained by the commentators (*ātmānama-ratninā prādeśena pakṣamityarthaḥ*—Karavinda). In the tail, the B_2 bricks on each side may start from the upper end at the junction with the body, leaving 12 *aṅgulas* (*prādeśakṣetra)* at the end, as it appears from Sundararāja, or from the western end of the tail leaving the *prādeśakṣetra* adjacent to the body, as is preferred by Karavinda. Both Sundararāja and Karavinda place 2 B_4 bricks at each end of the *prādeśakṣetra* and 4 B_3s in the middle (Fig. 9(a)). Kapardi places 2 B_3s in the middle flanked on each side by 3 B_4s (Fig. 9(b)). In the former arrangement, the number of bricks total 166, and in the latter 168, as detailed in Table I.

Table 1. *Bricks in different parts of the citi—first layer; figures within parenthesis are according to Kapardi.*

Parts of the *citi*	Brick types				Total
	B_1	B_2	B_3	B_4	
Body, including bricks at the junctures	60	30			90 (90)
Wings	40	10			50 (50)
Tail	10	10	4 (2)	2 (6)	26 (28)
Total	110	50	4 (2)	2 (6)	166 (168)

For 166 bricks, the deficit is 34. Sundararāja proposes to replace 4 B_1s from the middle of the body by 36 B_5s and again 2 B_1s from the end of the tail by 4 B_3s.

10.4-10.6. In describing the arrangement of bricks in the second layer in these *sūtras,* care is taken that the edges of bricks in the two layers do not meet. This is achieved by placing 10 B_2 bricks turned towards north or south along the southern and the northern side of the body and interchanging the arrangement of bricks between the tail and the wing. Thus B_2 bricks placed at the juncture between the wing and the body in the first layer are now placed at that between the tail and the body, with 1 *aratni* or 24 *aṅgulas* lying within the tail and 12 *aṅgulas* within the body. (*tāsāmardheṣṭakāmātrāṇyātmani bhavanti/pucche'ratnimātrāṇi*/Sundararāja.). Since 12 *aṅgulas* of these bricks project into the body, these are covered, according to the commentators, by 5 B_3s to enable the filling up of the remaining space with B_1s. In the first layer, 5 B_2s lined each side of the tail. This arrangement is to be followed in the case of the wings for the second layer with the modification that on each side of the wing the number of B_2s should now be 6 because of the extension of the wing by one *aratni*. The different types of bricks arranged in the above manner total 163, as mentioned by Karavinda and in Fig. 10 and Table 2.

Fig. 10. Arrangement of bricks in the second layer of a *caturaśra śyenacit*.

Table 2. *Bricks in different parts of the citi, second layer.*

Parts of *citi*	Brick types			Total
	B_1	B_2	B_3	
Body, including bricks at the juncture	65	20	5	90
Wings	24	24		48
Tail	15	10		25
Total	104	54	5	163

Now, 37 bricks are still required to make the number 200. According to Karavinda, 4 B_1s, one each from the body, the wings and the tail, are replaced by 36 B_5s; 5 B_1s in the middle of the easternmost row in the body are replaced by 10 B_3s. (*atra pakṣayorātmani pucche catasraḥ pañcamabhāgiyā uddhṛtya ṣaṭtriṃśataṃ pañcadaśabhāgiyā upadadhyāt/ātmani pūrvasyāṃ rītyāṃ madhye pañcoddhṛtya daśārdheṣṭakā udīcīrupadadhyādevaṃ dviśataḥ prastāraḥ/*)

The first and the second layers are then repeated alternately up to as many layers as desired.

10.7-10.10. These *sūtras* do not call for much explanation. *puriṣa* is loose earth moistened with water,—*jalādrā mṛt puriṣam* (Karavinda) and is applied for purposes of bonding, for filling up crevices etc.

CHAPTER 11

CONSTRUCTION OF A RECTILINEAR *ŚYENACIT* WITH SQUARE BRICKS

11.1-11.4. In this chapter, another method of constructing a rectilinear *śyenacit* is described, in which only square bricks are employed. These bricks are :

B_1 — one-fourth (of a *puruṣa*), *caturbhāgiyā, aṇuka* — 30 × 30 *aṅg*²
B_2 — one-fifth, *pañcamabhāgiyā, aratni* — 24 × 24 ,,
B_3 — one-sixth, *ūrvasthi, ṣaḍbhāgiyā* — 20 × 20 ,,
B_4 — quarter of one-fourth, *aṇukapādā, caturbhāgiyapādā* — 15 × 15 ,,
B_5 — quarter of one-fifth, *pañcamabhāgiyapādā* — 12 × 12 ,,

aṇuka means one-fourth of a *puruṣa*, i.e. 30 *aṅgulas*; *aratni* has already been explained; *ūrvasthi* stands for one-sixth of a *puruṣa*, i.e. 20 *aṅgulas* (*puruṣasya ṣaṣṭho bhāga ūrvasthi*-Karavinda). *pāda* is a quarter; by using it with bricks of size one-fourth, one-fifth etc. of a *puruṣa*, their quarter bricks are indicated.

11.5-11.8. The plan of placing bricks in the first layer is shown in Fig. 11. The number of bricks used in different parts of the fire-altar, as per explanations of the commentators, are shown in Table 3.

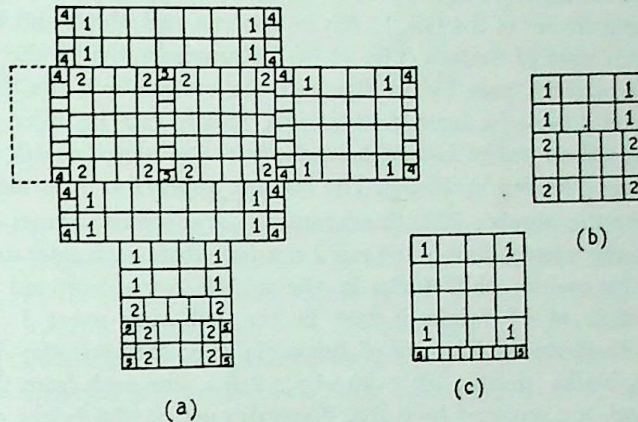



Fig. 11. Arrangement of square bricks in the first layer of a *caturaśra śyenacit*; bricks in the tail in (a) due to Kapardisvāmī, in (b) due to Karavinda and in (c) due to Sundararāja.

The direction for the placement of 8 B_4 bricks on each of the two ends of the wings and at their junctions with the body is clear. About the four corners of the body, the commentators explain that 4 B_4s should be placed at each along west-east or east-west. At the junctures, these bricks lie 6 *aṅgulas* within the body, leaving a rectangular space 228 × 120 *aṅg*^{2} in the body *(sandhāntarāla)* to be filled by B_2 bricks and their quarters, B_5. Clearly, there can be only 9 rows of 5 B_2 bricks each,

Table 3. *Bricks in different parts of the citi, first layer; following Kapardisvāmī, Karavindasvāmī and Sundararāja*

Parts of the *citi*	Kapardisvāmī					Karavindasvāmī					Sundararāja				
	Brick type				Total	Brick type				Total	Brick type				Total
	B_1	B_2	B_4	B_5		B_1	B_2	B_4	B_5		B_1	B_2	B_4	B_5	
Body	28	45	16	10	99	28	45	16	10	99	28	45	16	10	99
Wings, including brick at junctions	32		32		64	32		32		64	32		32		64
Tail	8	13		8	29	8	15			23	16			10	26
Total	68	58	48	18	192	68	60	48	10	186	76	45	48	20	189

leaving a rectangular strip which can be fitted by 10 B_5 bricks only. According to Kapardi and Karavinda, the B_5 row is to be so placed that there are 25 B_2s south of it and 20 B_2s north of it (as shown in Fig. 11). (*tāsaṃ dakṣiṇataḥ pañcaviṃśatiḥ pañcamabhāgiyāḥ / uttarato viṃśatiḥ /*). Sundararāja prescribes the opposite, saying that the other arrangement is also permissible. The remaining space in each wing can be filled by 16 B_1s and that in the body by 28 B_1s.

As regards the tail, the direction in the *sūtra* being insufficient, the commentators have suggested different arrangements. Kapardi places 4 B_5s on each side at the western corner of the tail, 13 B_2s in between and above and 8 B_1s in the remaining eastern part of the tail (Fig. 11 (a)). Karavinda divides the tail in two parts filling the western part by 15 B_2s and the eastern by 8 B_1s (Fig. 11(b)). Sundararāja takes *prādeśa* to mean *prādeśakṣetra,* which can be filled by 10 B_5s (*pucchāgre yatpravṛddhaṃ prādeśakṣetraṃ tadupadadhyāt sāmarthyāddaśabhiḥ prādeśaḥ/*); the remaining space is filled by 16 B_1s. The last one appears to be straightforward.

To complete the number 200, Sundararāja's arrangement shows a deficit of 11 bricks. From the western half of the tail 2 B_1s (one from each side) are replaced by 8 B_4s; in the eastern half, 4 B_1s in the middle are substituted by 9 B_3s. Karavinda's deficit of 14 bricks is met in the following way: 1 B_1 in the body immediately above the fifth row of bricks (in the *sandhāntarāla*) is replaced by 9 quarter B_3 bricks (that is, 10×10 *aṅg*^{2}); 2 B_2s, one each from the western corners of the tail, are replaced by 8 B_5s. Kapardi's deficit of 8 bricks can be met by replacing 1 B_1 by 9 quarter B_3s, as in the case of Karavinda.

11.9-11.11. In the arrangement of bricks in the second layer, 5 B_2 bricks are placed at the juncture between the tail and the body, half of them lying on either side. 14 B_5s are placed around the aforesaid bricks, 10 east of them and 2 on each side. The remaining space in the body can be filled with 94 bricks, thus accounting for 113 bricks in the body with the junction, of which B_2s are 99 and B_5s are 14. In each wing 30 B_2s are placed, so that there are 60 bricks in the two wings. In the tail, following Karavinda, 9 B_3 bricks are placed in the upper half immediately after the junction bricks, in three rows,—two on the sides and one in the middle.

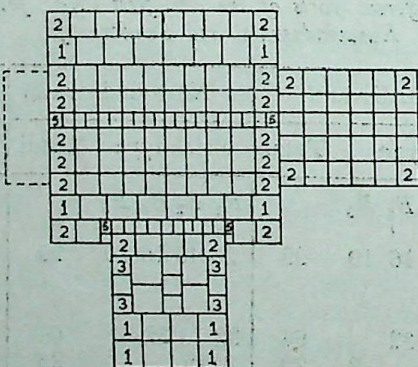
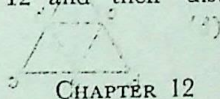



Fig. 12. Arrangement of square bricks in the second layer; total number of 200 bricks is shown after adjustments.

The remaining space is filled with 12 B_1s. In Sundararāja's scheme, the arrangement is reversed, the B_3 rows appearing in the lower part of the tail.

Table 4. *Bricks in different parts of the citi, second layer*

Parts of the *citi*	Brick types				Total
	B_1	B_2	B_3	B_5	
Body, including juncture	16	69		34	119
Wings		60			60
Tail	12		9		21
Total	28	129	9	34	200

In this way 194 bricks are accounted for. To complete the number of 200 bricks, the following adjustments are proposed by the commentators. There are 10 rows, south-north, in the body, including bricks at the juncture. 10 B_2s in each of the 2nd and the 9th row are replaced by 8 B_1s each and 10 B_2s in the 6th by 20 B_5s. with a gain of 6 bricks to make up the deficit. The arrangement of bricks with these adjustments is shown in Fig. 12 and their distribution over various parts in Table 4.

Chapter 12

FIRE-ALTARS OF AREAS ONE-FOLD AND UPWARDS, AND FIRE-ALTARS IN THE FORM OF ISOSCELES TRIANGLE, RHOMBUS AND CHARIOT WHEEL

12.1. The side of an one-fold fire-altar of area 1 sq. *pu.* is 120 *aṅg* ; that of a six-fold fire-altar is 293 *aṅg* 31 *tilas.* Baudhāyana (*Bśl.* 5.8-5.15) has discussed the question of fire-altars smaller than $7\frac{1}{2}$ sq. *pu.* Here it is maintained that no fire-altar smaller than the seven-fold should be used, although some teachers uphold the legitimacy of fire-altars from $1\frac{1}{2}$ to $6\frac{1}{2}$ sq. *pu.* Such smaller fire-altars may be constructed but then only in the form of *praugas*, *rathacakras* etc.

12.3. The *kāmyas* (desires) are different forms of the seven-fold fire-altar. *Guṇas* (qualities) are six in number (Karavinda). For *guṇavikāra* see *Āśr.* 14.1, 1).

The fire-altar in the form of an Isosceles Triangle *(PRAUGACITI)*

12.4-12.6. The fire-altars in the form of isosceles triangles *(prauga)* are discussed in these *sūtras*. The *prauga* has been likened to the fore part of a cart *(śakaṭa-mukha)*. The method of transforming a square (or a rectangle) into an isosceles triangle has been discussed by Baudhāyana (*Bśl.* 1.7). The construction of a fire-altar in the form of an isosceles triangle and the various types of bricks employed are fully discussed in *Bśl.* 14.1-14.8. Baudhāyana advises the use of rectangular *bṛhatī* bricks and their triangular halves and quarters by cutting the *bṛhatīs* diagonally.

Āpastamba advises the use of isosceles triangular bricks of different sizes, as explained by his commentators. Since the isosceles triangle ABC formed out of the square $EBCD$ is $\frac{15}{2}$ sq. *pu.* we have (Fig. (13(a)):

$BC = AF = \sqrt{15}$ *pu* $= 120\sqrt{15}$ *aṅg* $= 464$ *aṅg* 22 *ti* (approx.)

$AB = 300\sqrt{3}$ *aṅg* $= 519$ *aṅg* 21 *ti*. (= 4 *pu.* 39 *aṅg.* 21 *ti,* Karavinda)

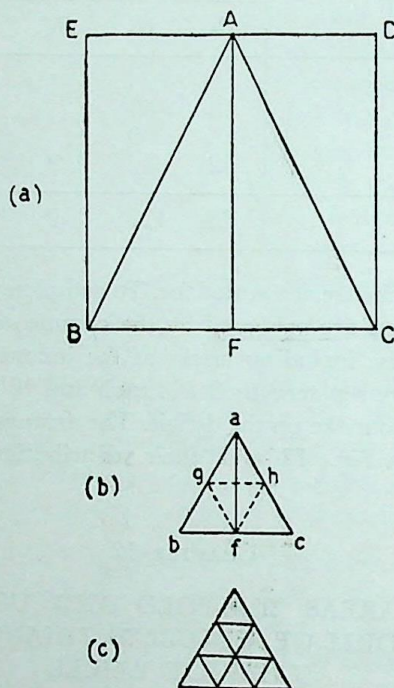



Fig. 13 (a). An isosceles triangle from a square. (b) *dvādaśi* bricks and their subdivisions. (c) *trayodaśi* bricks and their subdivisions.

The one-twelfth brick, *abc,* for the first layer has each of its two equal sides one-twelfth of AB or AC and the base one-twelfth of BC The half bricks are obtained by dividing *abc* vertically by *af*, and the quarter bricks by joining the mid-points *g*, *h*, *f* of the three sides (Fig. 13(b)). Sundararāja prescribes the use of one-ninth bricks by trisecting the three sides of the one-twelfth brick and joining them, as shown in Fig. 13 (c). For the second layer, one-thirteenth and their subdivisions are used. The dimensions are:

B_1 — one-twelfth *(dvādaśi)* isosceles triangular: side — 43 *aṅg* 10 *ti,* base — 38 *aṅg* 25 *ti* (Karavinda) ;

B_2 — half of one-twelfth—43 *aṅg* 10 *ti*; 38 *aṅg* 25 *ti*; 19 *aṅg* 12½ *ti.*;

B'_1 — one-thirteenth *(trayodaśi)* isosceles triangular: side—39 *aṅg* 33 *ti* (= 40 *aṅg*—1 *ti*) ; base—35 *aṅg* 25 *ti.* ;

B'_2 = half of one-thirteenth—39 *aṅg* 33 *ti*; 35 *aṅg.* 25 *ti*; 17 *aṅg* 29½ *ti.*

All these values agree with Karavinda's. Dimensions of quarter and one-ninth bricks are not given.

If for the first layer, the two sides and the base are divided into 12 equal parts and the dividing points joined parallel to the sides and the base, the whole area will be divided into 144 isosceles triangles, each to be fitted exactly by the one-twelfth brick. The number 144 can be computed by permutation because, starting with one triangle at the apex it increases to 23 at the 12th layer with a common difference 2. For the second layer, where the sides are to be divided into 13 equal parts, there are likewise 169 triangles, each to be exactly fitted by one-thirteenth brick. Thus Sundararāja says: *prathame prastāre catuścatvāriṃśacchatena dvādaśibhirudicyo dvādaśa ritayaḥ |...aparasmin prastāre trayodaśibhiḥ navaṣaṣṭiśatena trayodaśa ritayaḥ |* To complete the number of 200 bricks, in the first layer, 16 one-twelfth bricks in the middle four rows are replaced by 64 quarter bricks, and the apical brick is replaced by 9 one-ninth bricks, thus making up the deficit of 56 bricks. In the second layer, in place of 7 one-thirteenth bricks, 20 quarter and 18 one-ninth bricks are added to make good the deficit of 31 bricks.

The Fire-altar in the form of a Rhombus *(UBHAYATA PRAUGA)*.

12.7-12.8. For the construction of a rhombus or two isosceles triangles on either side of the common base, Baudhyāyana's rules, *Bśl.* 2.8 may be referred to. The seven-fold fire-altar in the form of a rhombus, with the types of bricks to be used, has been discussed by Baudhāyana (*Bśl.* 15.1-15.6). In the case of the rhombus fire-altar, the bricks are to be made as in the case of the *praugaciti,* and these should be in the form of a rhombus, as Karavinda explains (*karaṇāni cayanavidhiśca praugavat | viśeṣaḥtūbhayataḥ praugāḥ iṣṭakāḥ|*)

The Fire-altar in the form of a Chariot Wheel *(RATHACAKRACIT)*.

12.9-12.10. These two *sūtras* and the first three (13.1-13.3) of the next chapter deal with the construction of the fire-altar in the form of a chariot wheel. Āpastamba refers to the same type of *rathacakraciti,* as discussed in detail by Baudhāyana (*Bśl.* 16.1-16.5) and explained in the notes concerning these *sūtras.*

Chapter 13

CONSTRUCTION OF FIRE-ALTARS IN THE FORM OF A CHARIOT WHEEL *(RATHACAKRA)* AND A TROUGH *(DROṆA)*

13.1-13.3. As mentioned in the previous chapter, these three rules are in continuation of *sūtras* 12.9 and 12.10, dealing with the construction of a *rathacakracit.* This type has been fully discussed in connection with Baudhāyana's rules describing such a fire-altar (*Bśl.* 16-16.5).

The Fire-altar in the form of a Trough *(DROṆA)*.

13.4-13.16. Of the two types of fire-altars in the form of a trough *(droṇa)*, the square type in which both the body and the handle are squares is here described. The

circular type is not discussed. Baudhāyana, as we have noticed, discussed both the types,— square-type in rules *Bśl.* 17.1-17.12, and the circular type in *Bśl.* 18.1-18.11.

In Āpastamba's *droṇaciti,* the relative areas of the handle and the body of the trough are different from those prescribed by Baudhāyana. The area of the seven-fold fire-altar being 108000 sq. *aṅg.,* the handle measures 10800 sq. *aṅg.* and the body 97200 sq. *aṅg.* The area of the square body is 9 times that of the square handle and therefore the side of the handle is one-third of the side of the body. The sides are :

The side of the body = 311 *aṅg.* 26.18 *ti* = 312 *aṅg*—8 *ti* approx. as given by Karavinda and Sundararāja.

The side of the handle = 103 *aṅg.* 31.28 *ti.*

The bricks are formed by the twelfth part of the side of the body, and out of such *dvādaśi* square bricks, *adhyardhā* (one side longer by half), quarter bricks etc. are formed, of which specifications are as follows:

B_1 — one-twelfth or *dvādaśabhāgiyā* square brick : side-25 *aṅg.* 33 *ti* = 26 *aṅg.*—1 *ti* ;

B_2 — *adhyardhā* of one-twelfth—38 *aṅg.* 33 *ti* × 25 *aṅg.* 33 *ti* ;

B_3 — quarter of one-twelfth ;

B_4 — quarter of *adhyardhā.*

B_3 and B_4 are used to make the total number of bricks in a layer equal to 200. Sundararāja mentions one-ninth bricks.

The arrangement of bricks in the first and the second layers, for which the directions in the *sūtras* are quite clear, are shown in Fig. 14(a) and (b). In the first layer, 24 B_2 bricks are placed,—12 on the eastern side, 4 each on the two western

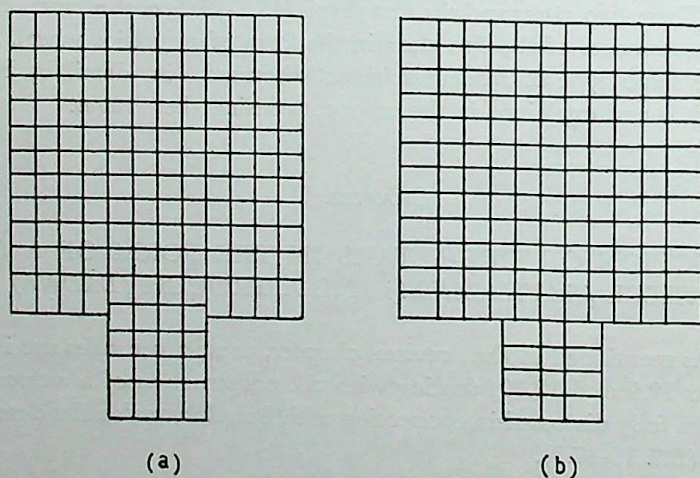



Fig. 14. Fire-altar in the form of a trough : (a) first layer, (b) second layer.

sides of the body and 4 at the western end of the handle. The remaining space can just accommodate 124 B_1 bricks. The total number of bricks comes to 148. In the

second layer, the rule prescribes the use of 32 B_2s,—24 in the body and 8 in the handle; the remaining space can be filled with 112 B_1s, making the total number 144. The deficit in either layer is made up by replacing the required number of B_1s and B_2s by quarter bricks.

CHAPTERS 15, 16 AND 17

CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A FALCON WITH CURVED WINGS AND EXTENDED TAIL—FIRST TYPE

We have already met with Baudhāyana's construction of two types of fire-altars in the form of a falcon with curved wings and extended tail (1st. type, *Bśl.* 10.1-10.20, 2nd. type, *Bśl.* 11.1-11.13). Āpastamba gives the construction of two other types, of which the first one is described in these three chapters, and the second one in chapters 18 to 20 to follow. We have thought it convenient to deal with these three chapters together because of the continuity and overlapping of the subject matter.

15.2. In the falcon-shaped fire-altar, a head is to be provided, the tail should be spread out and each wing must be curved. According to rule 15.2, the curving of the wing is to be done by pushing the west side upwards and the east-side downwards. Karavinda explains that what actually should be done is to raise upwards towards east the first half of the wing from its root at the body to the middle and to press downward towards west the second half from the middle to the end. (*prathama pakṣārdhaṃ mūlādārabhya paścātprabhṛti prāgunnayet |.. dvayaṃ pakṣārdhaṃ madhyādārabhya purastāt prabhṛti pratyagunnayet |*). The method is further explained in rule 15.6.

15.2-15.5. *Areas of different parts of the falcon.* A simple rectilinear *śyenacit,* as we have already noticed (*Bśl.* chs. 8 and 9; *Āśl.* chs. 10 and 11), consists of a square body of 240 × 240 sq. *aṅg.* (4 sq. *pu.*), two rectangular wings each of 144 × 120 sq. *aṅg.* ($1\frac{1}{5}$ sq. *pu.*) and a rectangular tail of 132 × 120 sq. *aṅg.* ($1\frac{1}{10}$ sq. *pu.*). Some areas are taken out from the tail and the body *(ātman)* of the rectilinear *śyenacit* to build up the head and extend the area of each wing in the following manner :

Area taken out of the tail—120 × 12 sq. *aṅg.* or $\frac{1}{10}$ sq. *pu.*

Area taken out of the head—(120 × 120 + 8 × 900) sq. *aṅg.* or $1\frac{1}{2}$ sq. *pu.*

Caturbhāgiyā is the area of a square of side 30 *aṅg.*, that is 900 sq. *aṅg.*

The area of the head, which is built out of 3 *caturbhāgiyās,* is 2700 sq. *aṅg.* or $\frac{3}{16}$ sq. *pu.*

The area of the tail, after the *prādeśa* portion is taken out, is 14400 sq. *aṅg.* or 1 sq. *pu.*

The area of the body, after $1\frac{1}{2}$ sq. *pu.* are taken out, is $2\frac{1}{2}$ sq. *pu.* or 36,000 sq. *aṅg.*

Since the area taken out of the tail and the body less that used for making the head is added to the wings, the area of each wing is determined as follows :

The total area added = $(120 \times 12 + 120 \times 120 + 5 \times 900)$ sq. *aṅg.*
= 20, 340 sq. *aṅg.* or $\frac{113}{80}$ sq. *pu.*
The area added to each wing = 10, 170 sq. *aṅg.*
= $120 \times 84\frac{3}{4}$ sq. *ang.*
The area of each extended wing = $(120 \times 144 + 120 \times 84\frac{3}{4})$ sq. *aṅg.*
= $120 \times 228\frac{3}{4}$ sq. *aṅg.*

The area of two extended wings = $2 \times 120 \times 228\frac{3}{4}$ sq. *aṅg.* or $\frac{61}{16}$ sq. *pu.* The rules direct to increase the length of the rectangular wing without changing its breadth of 1 *puruṣa* or 120 *aṅg.* The new length of the extended rectangular wing is clearly $228\frac{3}{4}$ *aṅg.* or $9\frac{1}{2}$ *aratnis* plus $\frac{3}{4}$ *aṅg.*, according to the definition of the units given in rule 15.4. This new length of the wing is stated in rule 15.5. Note that the total area, after distribution, of the fire-altar, remains $7\frac{1}{2}$ sq. *pu.* $(= \frac{3}{16} + 1 + \frac{5}{2} + \frac{61}{16})$.

Shapes of different parts of the falcon. The constructions of the different parts of the falcon are given in rules 15.6-15.9 and 16.1.

15.6. *The wing.* For the construction of the wing, a rectangle *ABCD* is taken, such that *AB* equals 120 *aṅg.* and *AD* $228\frac{3}{4}$ *aṅg.* (Fig. 15(a)). Upon *BC* and *AD,* the triangles *BFC* and *AED* are constructed. *BF, CF, AE, DE* each equals 120 *aṅg.* *AEDCFB* is the new shape of the wing in which the bending *(nirṇāma)* takes place at *E* and *F.*

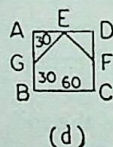
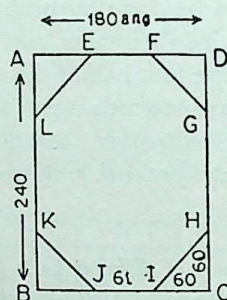
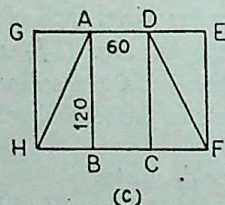
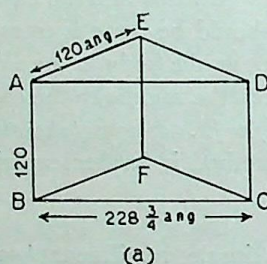



Fig. 15. Different parts of the falcon with curved wings and extended tail : (a) wing, (b) body, (c) tail, and (d) head.

15.7-16.1. *The body* : A rectangle *ABCD,* of which *AB* equals 240 *aṅg.* and *AD* 180 *aṅg.*, is formed (Fig. 15(b)). At each of the 4 corners an isosceles triangle of side equal to 60 *aṅg.* is formed and cut off from the rectangle by transverse lines *EL, FG,* etc. as shown. The length *EF* at the eastern and *IJ* at the western side equals 60 *aṅg.*, *GH* on the southern and *KL* northern side equals 120 *aṅg.* The area of the figure *EFGHIJKLE* exactly equals 36,000 sq. *aṅg.* or $2\frac{1}{2}$ sq. *pu.*

15.8. *The tail.* The rectangle *ABCD*, of which *AB* equals 120 *aṅg.* and *AD* 60 *aṅg.* is flanked on its southern and northern sides by two rectangles *DEFC* and *AGHB* which are cut off by the diagonals *DF* and *AH* respectively, leading to the figure *ADFHA* which is the shape of the tail (Fig. 15(c)). *AD* equals 60 *aṅg.* and *HF* 180 *aṅg.*

15.9. *The head.* A square *ABCD* of which each side equals 60 *aṅg.* is constructed (Fig. 15(d)). From the mid-point *E* of *AD*, *EF* and *EG* are drawn to the mid-points *F* and *G* of *DC* and *AB* respectively. *EFCBGE* is the shape of the head.

Note that either side of the wing *AB*, *CD* will join exactly with either the south side *GH* or the north side *KL*. Similarly, the base of the head *BC* will fit in exactly with the eastern side *EF* of the body and the eastern side *AD* of the tail with the

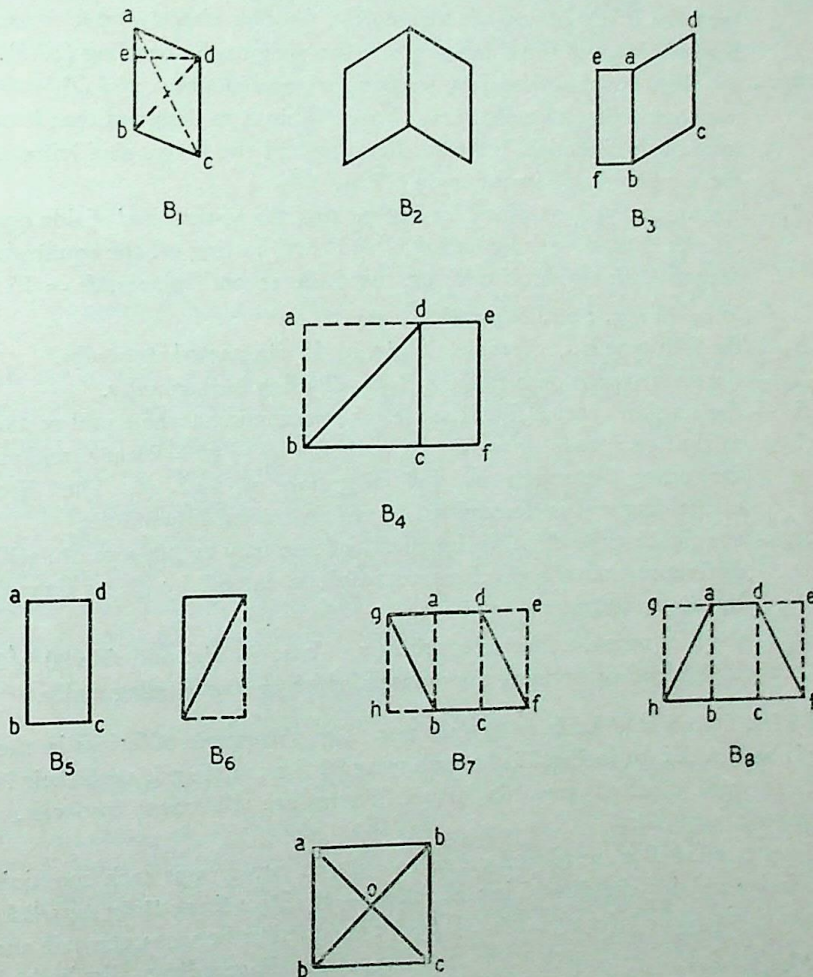



Fig. 16. Nine types of bricks for the falcon-shaped fire-altar.

western side *JI* of the body. These junction lines are the *apyayas*. The four corners of the body are thus cut by lines *EL, FG, HI,* and *JK* joining the extremities of the *apyayas*, as proposed in the rule 16.1.

16.2-16.10. *Types of Bricks*. Nine types of bricks have been used in covering the alternate layers of this fire-altar. These are :

B_1 — the first type,—a parallelogram *abcd,* of which $ab = cd = 24$ *aṅg.* and $ad = bc = 20$ *aṅg.* (Fig. 16). The sides are parallel to those of the parallelogram *ABEF* or *CDEF*, so that this type can fit in the wings. Sundararāja gives the values of the longer diagonal *ac* as 35 *aṅg.* 20 *ti* and of *bd* as 26 *aṅg.* 6 *ti*. He also gives the breadth *ed* between the longer sides as 19 *aṅg.* 2 *ti,* which is $\frac{1}{12}$ of $228\frac{1}{4}$ *aṅg.* (the length of the wing).

B_2 — the second type, obtained by joining 2 B_1s along the longer side such that the brick is bent at the middle (*madhye nirṇatā ekapārśve unnatā*—Karavinda) and suitable for use in the wing at the bending (17.5).

B_3 — the third type, obtained by joining the parallelogram *abcd* (B_1) with the rectangle *aefb* along *ab*; $ae = 15$ *aṅg.* This is so designed that it can be used at the junction between the wing and the body, *abcd* lying within the wing and *aefb* in the body (17.5).

B_4 — the fourth type, obtained by first making the square *abcd* of side equal to 30 *aṅg.* extending it by half *defc,* and then cutting off the square by the diagonal *bd*; *defbd* is the brick, used in several places. $de = 15$ *aṅg.*, $bf = 45$ *aṅg.* ; and $bd = 30\sqrt{2}$ *aṅg.*

B_5 — the fifth type is a rectangle, 30 *aṅg.* by 15 *aṅg.*; *caturbhāgiyārdha.*

B_6 — the sixth type is derived from B_5 by dividing it diagonally.

B_7 — the seventh type, *gbfdg,* is made by constructing three equal rectangles, so that $ad = de = ag = 12$ *aṅg.* and $ab = ef = gh = 24$ *aṅg.* and cutting the outer rectangles by the diagonals *df* and *gb*. The direction of the diagonal is determined by *dakṣiṇāvarayoḥ koṭyorālikhet.*

B_8 — the eighth type *ahfda,* is done in the same way as the seventh, with the difference that the northern rectangle is cut off by *ah,* as determined by *uttaraṃ tūttarasyāḥ koṭyā* etc.

B_9 — the ninth type, an isosceles triangle of base 30 *aṅg.* and side $30\sqrt{2}$ *aṅg,* is obtained by dividing the square *abcd* ($ab = 30$ *aṅg.*) diagonally.

16.11-17.4. *Placement of bricks in the first layer*. The placement of bricks in the first layer is best explained in Fig. 17. In each wing 60 B_1s are placed, with their longer sides, 24 *aṅg.* directed towards north. There are 10 rows east-west, each accommodating 6 B_1s.

In the tail, 8 B_6s are placed on either side, in two groups each containing 4. Karavinda explains the disposition as follows—*pucchāgre tisraḥ tāsāṃ purastādekam | evamuttarasmin pārśve viparyasya kāritāḥ |* At the junction between the tail and the body, 2 B_4s are placed in such a way that the portion diagonally cut lies in the body. West of them are placed 2 B_5s. The space now left in the tail consists of a rectangular strip, 30 *aṅg.* × 60 *aṅg.*, followed west of it by two equal rectangular strips, each 30 *aṅg.* × 120 *aṅg.* ; 10 B_4s $(2 + 4 + 4)$ can be placed in these three strips (17.1).

The body (*ātman*) can be divided into three distinct rows, east-west by the lines *GH, FI, EJ* and *LK*. The breadth of each row is 60 *aṅg.* In the four corner regions, 4 equal areas *EQRL, FMNG, IOPH* and *JSTK* can be marked out such that $EQ = FM = OI = JS = 75$ *aṅg.*; and $RL = NG = PH = TK = 15$ *aṅg.* In each of these four corner areas, 2 B_4s can be placed, with their diagonally cut edges pointing outwards and with their longer sides turned either towards east or west. (*ātmanaḥ śroṇyaṃseṣu dve dve bāhyaviśeṣe*-Sundararāja). Still an area 30 × 30 sq. *aṅg.* is left,

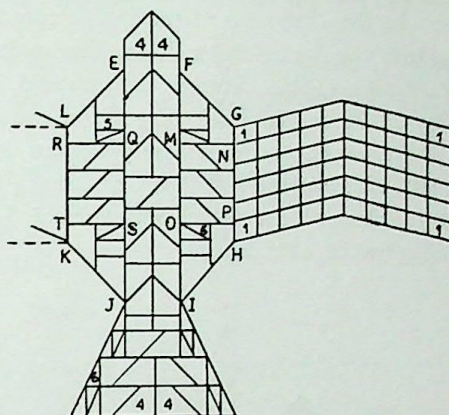



Fig. 17. Arrangement of bricks in the first layer of a *śyenacit* with curved wings and extended tail (after Thibaut). (North wing not shown).

which can be filled by 1 B_5 and 2 B_6s, thus requiring 4 B_5s and 8 B_6s as stated in the rule 17.2. The rectangular area *MNPO* and *QRTS* each measures 60 × 90 sq. *aṅg.* and can accommodate 6 B_4s each. In the central row 14 B_4s can be arranged as shown, leaving two isosceles triangular spaces of side 30 *aṅg.* Kapardi calls the central row *viśayānāṃ mārga,* as bricks at the junctures *(apyaya)* partly lie on either side; he also confirms 14 B_4 bricks in this row—*viśayānāṃ mārge tiryagātmani caturdaśa caturthyaḥ* / The space available in the head together with the two isosceles triangular areas can be exactly filled with 4 B_4 bricks as shown. The number of bricks and their types in the different parts of the fire-altar are given in Table 5.

Table 5. *Bricks in different parts of the citi—first layer.*

Parts of the *citi*	Brick types				Total
	B_1	B_4	B_5	B_6	
Head, including part of body		4			4
Body		34	4	8	46
Wings	120				120
Tail, including part of body		12	2	16	30
Total	120	50	6	24	200

17.5-17.10. *Placement of bricks in the second layer.* The arrangement of bricks of different types is shown in Fig. 18. In each wing, after placing 5 B_2s at the bending and 5 B_3s at the juncture between the wing and the body such that the extended rectangular part (15 × 24 sq. *aṅg*) lies in the body, the remaining space can accommodate 45 B_1s. 25 B_1s lie on the southern side and 20 B_1s on the northern side of the bending in the southern wing. In the northern wing the arrangement is opposite.

In the tail, 5 B_7 bricks are placed on either side, and the whole space is divided into 5 rows west-east. In the second and the fourth row from the bottom 1 B_7 each is placed by the side of the B_7s on either flank. This makes the total number of B_7s 12. (*evaṃ dvādaśa saptamya upahitā bhavanti* /-Karavinda). The remaining space in the tail is covered by 13 B_8 bricks. Their disposition is described by Karavinda as follows: *pucchāgre pārśvagatayossaptamyormadhye pañcāṣṭamyau / nanāgra dvitiyāyām/ tisrāṇāṃ saptamināṃ madhye tisro'ṣṭamyaḥ / tṛtiyāyāṃ ca tisraḥ / caturthariṭyāṃ tisrāṇāṃ saptamināṃ madhye ekā / pañcamariṭyāṃ saptamyormadhye ekā / evaṃ trayodaśāṣṭamyaḥ yathāyogaṃ prāgarāḥ pratyagagrāśca bhaveyuḥ //*

Fig. 18. Arrangement of bricks in the second layer (after Thibaut).

In the body, 2 B_4s, with their longer sides turned either towards north or towards south, but the diagonally cut side always facing outwards, are placed at each of the four corners. The remaining space can be divided into five rows east-west. The two rows on the south of the central row are filled with 10 B_4s, of which 5 are turned towards east and 5 towards west. The two rows north of the central are similarly filled with 10 B_4s. (*ātmano dakṣiṇe pārśve daśa caturthyaḥ / pañca-prāciḥ evamuttare pārśve*—Kapardi). The middle row can be filled with 32 B_6 bricks; but, to make the total number of bricks 200, 30 B_6s and 1 B_5 are used.

TABLE 6. *Bricks in different parts of the citi—second layer.*

Parts of the *citi*	Brick types									Total
	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9	
Head				2					4	6
Body				28	1	30				59
Wings, including part of body	90	10	10							110
Tail							12	13		25
Total	90	10	10	30	1	30	12	13	4	200

In the head, 2 B_4 bricks and east of them at the tip 4 B_9 bricks are placed. The number of bricks and their types used in the different parts of the fire-altar are shown in Table 6.

CHAPTERS 18, 19 AND 20

CONSTRUCTION OF A FIRE-ALTAR IN THE FORM OF A FALCON WITH CURVED WINGS AND EXTENDED TAIL—SECOND TYPE

18.1-18.2. These *sūtras* are repetitions of 15.1 and 15.2.

18.3. *Areas of different parts of the falcon.* One-sixteenth or *ṣoḍaśi* square bricks are used here for purposes of measurements. The same method was used by Baudhāyana for measuring the circular *droṇacit* (*Bśl.* 18.2). As already explained, the area is $\frac{1}{16}$ sq. *pu.* or 900 sq. *aṅg.*, that is, a square of side $\frac{1}{4}$ *pu.* or 30 *aṅg.* Clearly, 120 *ṣoḍaśi* bricks make $7\frac{1}{2}$ sq. *pu.* On this basis, measurements of the different parts of the fire-altar are as follows :

Head	— 3 *ṣoḍaśi*	$= \frac{3}{16}$ sq. *pu.*	or 2,700 sq. *aṅg.*
Body	— 40 ,,	$= \frac{5}{2}$,,	or 36,000 ,,
Wings	— 62 ,,	$= \frac{31}{8}$,,	or 55,800 ,,
Tail	— 15 ,,	$= \frac{15}{16}$,,	or 13,500 ,,
	120 ,,	$7\frac{1}{2}$,,	108,000 ,,

Note that the areas of the head and the body are the same as those of the first type of the falcon. Shapes of the different parts of the falcon are now described.

18.4. *The body.* It agrees with the body of the first type of falcon not only in area but also in shape (vide 15.7, 16.1). It is only differently described. One starts with the same rectangle of breadth $1\frac{1}{2}$ *pu.* or 180 *aṅg.* and length 2 *pu.* or 240 *aṅg.* The four corners are cut off, each by an isosceles right triangle of side 60 *aṅg.* (Fig. 15(b)). The area of each such triangle is 1800 sq. *aṅg.* equivalent of 2 *ṣoḍaśi* bricks, so that a total of 8 bricks are taken out from 48 bricks that the rectangle holds, leaving an area equivalent of 40 bricks. Regarding the cutting of the corners, Kapardi advises the construction of 4 squares of side $\frac{1}{2}$ *pu.* and cutting them off diagonally—*yathā śroṇyaṃseṣu catvāri caturaśrāṇi ardhapuruṣapramāṇāni kṛtvā akṣṇayānyārdhāni nirasyet.*

18.5. *The head.* This is done in the same way as the head in the first type (Fig. 15(d)). A square of side 60 *aṅg.* contains 4 *ṣoḍaśis* of which 1 is removed by the cutting off of the two eastern corners as described in the rule.

18.6-18.8. *The wings.* $\frac{1}{16}$ sq. *pu.* equals a rectangular area, 120 *aṅg.* long by $7\frac{1}{2}$ *aṅg.* broad. If this area is added to the rectangle, 240 *aṅg.* × 120 *aṅg.* along the common side 120 *aṅg.*, we get the rectangle $ABCD$ so that $AB = CD = 120$ *aṅg.* and $AD = BC = 247\frac{1}{2}$ *aṅg.* (Fig. 19(a)). About the addition of $7\frac{1}{2}$ *aṅg.* to the side 240 *aṅg.*, Kapardi says—*puruṣaṣoḍaśabhāgāścārdhonāṣṭāṅgulamātraṃ dakṣiṇe pakṣe cāyāmaḥ|*

At the end, the rectangular strip $EDFC$ of breadth 30 *aṅg.* is made and divided into 4 squares, 30 × 30 sq. *aṅg.* each. Each square is diagonally cut and the outer half removed. $ABCD$ whose area is $2\frac{1}{16}$ sq. *pu.* is equivalent of 33 *ṣoḍaśi* bricks. An area equivalent of 2 *ṣoḍaśis* is discarded by diagonally cutting the 4 squares, leaving an area equal to that of 31 *ṣoḍaśi* bricks.

In the middle of the rectangle less the portion where four squares were drawn up, the east-west line GHI is drawn perpendicular to the sides BF, AE. BF is $217\frac{1}{2}$ *aṅg.* and BI $108\frac{3}{4}$ *aṅg.* The point H on the east-west line is obtained by stretching a cord or a rod of 1 *pu.* such that BH equals 1 *p.u.* (Sundararāja explains—*pakṣasya sārdhasaptadaśadviśatāṅgulasya madhye lekhāṃ kṛtvā pakṣāpyasyāparānte puruṣamātraṃ veṇuṃ niyamya tasyāṃ lekhāyāṃ nipātayet | sā yatra nipatati lekhāyāṃ tatra nitodaṃ kuryāt |*)

The point G is obtained by making GH equal to 1 *pu.* GA, GE, HB and HF are joined. Each of these sides equals 1 *pu.* Thus $ABHFEGA$ together with the 4 diagonally intersected half squares EK_1L_1, $L_1K_2L_2$, $L_2K_3L_3$ and L_3CF at the south end represents the shape of the southern wing. The northern wing is obtained in the same manner.

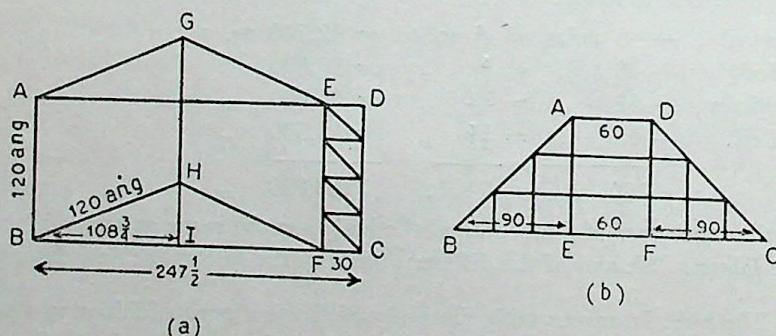



Fig. 19. Falcon-shaped fire-altar—(a) wing, (b) tail.

19.1. *The tail* . As per measurements given, $ABCD$ is the shape of the tail, where $AD = 60$ *aṅg.*, $BC = 240$ *aṅg.*, and AE $(= DF = BE = CF) = 90$ *aṅg.* The measurement of each of the two sides AB and DC is given in the text as *aṣṭādaśakaraṇi.* It means a side that produces a square equal to the area of 18 squares. Obviously,

these 18 squares are 18 *ṣoḍaśis*, that is, $\frac{18}{16}$ sq *pu.* or 900 × 18 sq. *aṅg.* The required side is therefore $\frac{1}{4}\sqrt{18}$ *pu.* or $30\sqrt{18}$ *aṅg.* The point is explained by Karavinda as follows: *aṣṭādaśa karotityaṣṭādaśakaraṇi / ṣoḍaśināṃ prakṛtatvāttāsāṃ aṣṭādaśānāṃ karaṇi / te khalu triṣoḍaśipramāṇanavatyaṅgulasamacaturaśrasyākṣṇayābhūte /* Thus, Karavinda puts it as the diagonal of a square of side 90 *aṅg.* (Fig. 19(b)), which again equals $30\sqrt{18}$ *aṅg.* That the area of the tail is equivalent to that of 15 *ṣoḍaśis* is clear from the figure.

19.2-19.8. *Types of bricks.* 6 types of bricks have been used in covering the alternate layers of the fire-altar. These are—

B_1 — the four-sided one-sixteenth *(śoḍaśi)* brick, of which $ab = \frac{1}{8}$ *pu.* or 15 *aṅg.*, $bc = \frac{1}{4}$ *pu.* or 30 *aṅg.*, $cd = \frac{3}{8}$ *pu.* or 45 *aṅg.* and $da = \frac{1}{4}\sqrt{2}$ *pu.* or $30\sqrt{2}$ *aṅg.* The area is $30 \times 15 + \frac{1}{2} \times 30 \times 30 = 900$ sq. *aṅg.*

B_2 — the half-brick *(ardheṣṭakā)*, *e,g.*, a half *ṣoḍaśi*, diagonally cut; $ab = bc = \frac{1}{4}$ *pu.* or 30 *aṅg.*, $ac = \frac{1}{4}\sqrt{2}$ *pu.*

B_3 — the quarter brick *(pādeṣṭakā)*, *e.g.* $\frac{1}{4}$ *ṣoḍāśi*, diagonally cut; $bc = \frac{1}{4}$ *pu*; $ab = ac = \frac{1}{8}\sqrt{2}$ *pu.* or $15\sqrt{2}$ *aṅg.*

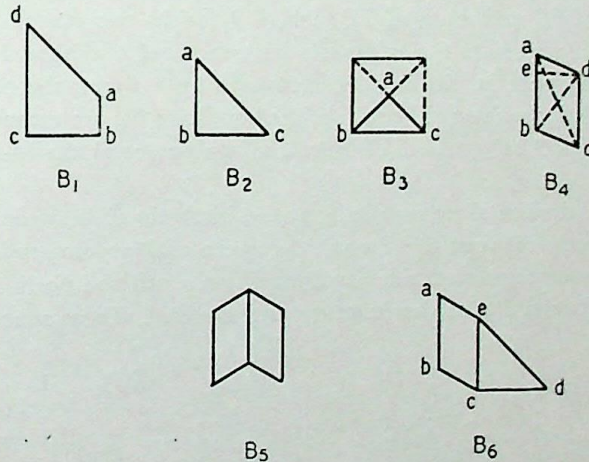



Fig. 20. Six types of bricks for the falcon-shaped fire-altar.

B_4 — the brick, suitable for use in either wing (*pakṣeṣṭakā*), is a parallelogram of sides $\frac{1}{4}$ and $\frac{1}{7}$ *pu.* The shape is so given that one diagonal *ac* is longer than the other *bd*, whose dimensions are given by Sundararāja as 40 *aṅg.* 12 *ti* and 27 *aṅg.* 20 *ti*. The purpose is to make it fit in the wing, so that the inclinations are similar to those of the wing at either side of the bending. Clearly *de* is $\frac{1}{7}$ of $108\frac{3}{4}$ *aṅg.* or 15 *aṅg.* $18\frac{3}{14}$ *ti* (Sundararāja gives this value as 15 *aṅg.* 18 *ti*). The shapes of B_4, B_5 and B_6 are further explained in 19.8.

B_5 — The brick suitable for use in the middle of the wing *(pakṣamadhyiyā)* at the bending. This is just 2 B_4s joined along the longer side.

B_6 — The brick suitable for use at the end of the tail *(pakṣāgriyā)* broken in the form of four triangles. It consists of two parts, e.g. parallelogram *abcd* and the triangle *ecd*, and is a combination of B_4 and B_2 joined about the common side $\frac{1}{4}$ *pu*. The inclination is so adjusted that the parallelogram part fits in the parallelogram part and the triangular in the triangular part of the wing.

19.9-20.4. *Placement of bricks in the first layer.* The placement of bricks is clearly explained in Fig. 21. The rules start with the placement of B_3 bricks, —4 at the tip of the head *ABC*, 5 west of the line *DE*, 11 east of the line *KF* joining the eastern points of juncture of the wings with the body, 11 west of *JG*, the western line of juncture, 5 each on the eastern and the western side of *IH*, the junction line between the tail and the body, and finally 15 at the end of the tail *LM*. Thus 56 B_3s are used (*tā evaitāḥ ṣaṭpañcāśatpādeṣṭakāḥ*—Kapardi).

4B_6*s* are placed at each end *OP* of the two wings, such that the triangular parts cover the triangular ends and the parallelogram parts part of the adjoining parallelogram of the wing. 4 B_6*s* are placed at either junction *FG*, *JK* of the wings with the body such that the triangular parts lie in the body. The total number of B_6*s* used is 16. North of *FG* and south of *JK* each, 4 B_1 bricks are placed in the body with their diagonally cut sides fitting exactly with the similar diagonal sides of the B_6*s*. The remaining space in either wing is covered by 4 B_5*s* at the bending *MN* and by 40 B_4*s*, —20 B_4*s* each on either side of the bending ; B_4*s* are turned eastwards. (*catvāriṃśatā catvāriṃśatā pakṣeṣṭakābhiḥ prāgāyatābhiḥ pakṣau pracchādayet*—Karavinda).

The spaces of the fire-altar now left out are in the head between the rows of B_3 bricks, in the body between the B_3*s* at the eastern and western ends and in the middle enclosed on east and west sides by B_3*s* and on south and north sides by B_1*s*, and in the tail between B_5*s* at the juncture and the end. These spaces are to be

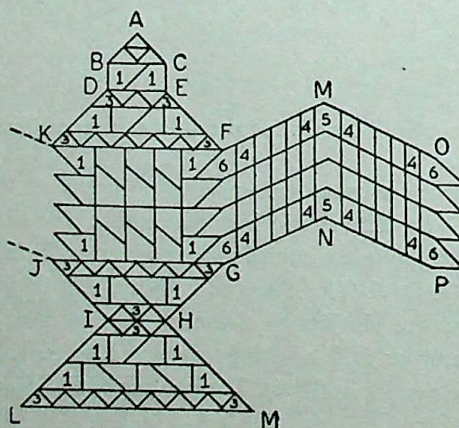



Fig. 21. Arrangement of bricks in the first layer of the *śyenacit* (2nd. type) with curved wings and extended tail (north wing not shown) (after Bürk).

covered by B_1s, such that at the inclined edges at the four corners of the body and the two sides of the tail, the diagonal sides ($\frac{1}{4}\sqrt{2}$ *pu.*, *saviśeṣāh*, as Kapardi explains) face outwards; elsewhere 2 B_1s lie with their diagonals touching each other so as to form a rectangle 60 *aṅg.* × 30 *aṅg.*, as the geometry clearly indicates. The number of bricks and their types in the different parts of the fire-altar are given in Table 7.

TABLE 7. *Bricks in different parts of the citi—first layer*

Parts of the *citi*	Brick types					Total
	B_1	B_3	B_4	B_5	B_6	
Head	2	4				6
Body	28	32				60
Wings, including part of body			80	8	16	104
Tail	10	20				30
Total	40	56	80	8	16	200

20.5-20.12. *Placement of bricks in the second layer.* In the second layer, 2 B_1s are placed at the tip of the head with their diagonal sides facing outwards. West of them 2 B_1s are placed, partly covering the head and the body, but with their diagonal sides facing inwards. There are two ways of doing it, as shown in Fig. 22(a) and (b). The space between the two diagonals is filled by 2 B_2s on each side of the 2 B_1s at the juncture, 1 B_2 being placed with its diagonal side facing outwards. Thereafter, B_1 bricks are to be placed at the corners of the body. Bürk, in his Fig. 63[a], placed 6 such bricks,—2 in the eastern and 4 in the western corners. All commentators have interpreted rule 20.7 as the placement of 4 B_1s, — one in each of the 4 corners (*śroṇyaṃseṣu catasraḥ ṣoḍaśyo vāhyaviśeṣāḥ pratyantaviśeṣāḥ*—Kapardi. *tāsāṃ sandhiṣu…* ……*ṣoḍaśyaḥ catasraḥ*—Karavinda.) The placing of 2 B_2s,—one on either side of the western corners, to maintain the symmetry with the eastern corners, has also been suggested. The rules then direct the placement of 4 B_2s at the end of each wing, 6 B_2s at both sides of the tail (3 on each) and B_4s in the wings turned towards north 20.8, 20.9). From the geometry of the wing, it is clear that the parallelogram spaces in either wing can be divided exactly into 56 (7 × 8) small parallelograms for containing 56 B_4s. Bürk's Fig. 63 shows 64 (8 × 8) which is incorrect. About 56 B_4s, Kapardi says : *ṣaṭpañcāśadviparyasya kāritāḥ;* about 7 rows south north, in the wings, Karavinda's statement is : *pakṣayorudicyaḥ pakṣeṣṭakāḥ sapta rītayaḥ* |

[a] Bürk, 385

Rule 20.10 directs that the remaining space in the body and the tail is to be covered by B_1s. Now, after covering the body with 4 B_1s and 4 B_2s and part of 2 B_1s at the juncture with the head (total area covered is equivalent of 7 *ṣoḍaśi* bricks), a space equivalent of 33 *ṣoḍaśi* bricks remains to be filled up; in the tail, the space yet to be covered is clearly that of 12 *ṣoḍaśis*. Hence, Karavinda's comment—*avaśiṣṭamātmani trayastriṃśat ṣoḍaśisthānaṃ pucchadvādaśa ṣoḍaśisthānaṃ*. With 18 bricks placed in the head, body and tail, 120 in the two wings and 45 *ṣoḍaśi*-spaces, the total number comes to 183. Then the geometry of the remaining space in the body is such that only 30 B_1s can be accommodated and the remaining three *ṣoḍaśi* spaces (30×30 sq. *aṅg.*) can be covered by 4 B_2s and 4 B_3s (20.11). In that way, Kapardi arrived at 188 bricks, still short of 12 (*evaṃ dvādaśonaṃ śatadvayam* /) The arrangement of 188 bricks is shown in Fig. 22(a).

The deficit of 12 bricks can be met by replacing 12 B_1s by B_2s and B_3s, as indicated in 20.11. The role of *aṇukās*, 30×30 sq. *aṅg.*, in parallelogram form is not properly understood, for the same objective can be achieved by half bricks (B_2).

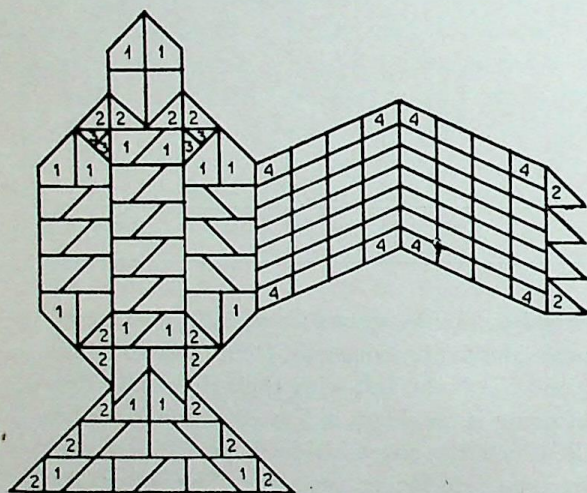



Fig. 22(a). Arrangement of bricks in the second layer, following Kapardi, and showing the deficit of 12 bricks. (North wing not shown).

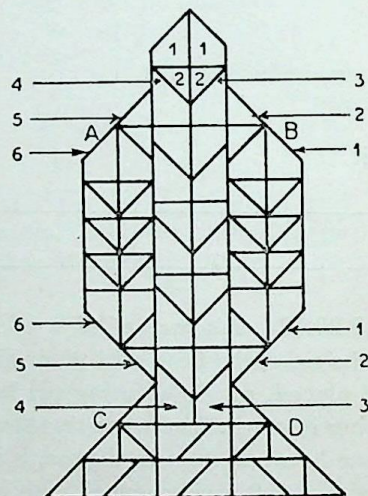



Fig. 22(b). Arrangement of bricks in the second layer, following Karavinda, showing the placement in the head, body and tail only.

However, a complete scheme explaining how 200 bricks can be laid in the second layer has been given by Karavinda. There is no change in the arrangement of bricks in the two wings, totalling 120. Accordingly, the placement of bricks in the head, the body and the tail only is shown in Fig. 22(b). The head and its juncture with the body are covered, as in Fig. 22(a), by 4 B_1s and 2 B_2s; at the juncture the dispositions of 2 B_1s and 2 B_2s are reversed : *śirasi prāṅmukhe bāhyaviśeṣe dve ṣoḍaśyau upadadhyāt / tayoḥ paścāt prāṅmukhe bāhyaviśeṣe viśaye dve ardhe / tayoḥ*

paścāttadviśeṣaśliṣṭaviśeṣe dve ṣoḍaśyau viśaye ātmani / The bricks at the *viśaya* are flanked on either side by 1 B_2 as before, forming a line AB.

The body west of the line AB is divided into six rows in the east-west direction : *tataḥ paścāt ātmani prācyaṣṣaḍritayaḥ* / Beginning from the south, the first row contains 8 bricks,—1 B_1 at each of the eastern and the western corners and 6 B_2s in between. The second row has 2 B_1s at the western corner end, then 1 B_1, 6 B_2s, again 1 B_1 and 2 B_2s, of which the one at the eastern corner has already been mentioned. There are thus 12 bricks (*dvādaśeṣṭakā eṣā* /) In the third layer, starting from west of the juncture line AB upto the line of juncture CD in the tail, there are 8 B_1s, of which 4 are turned eastwards and 4 westwards : *tṛtīyasyaṃ rityāṃ śiro'pyayaṣoḍaśyāḥ paścādārabhya āpucchāpyayamaṣṭau ṣoḍaśya upadheyāḥ / tāsāṃ catasraḥ prācyaścatasraḥ pratīcyaḥ*/ The arrangements in the 4th, 5th and 6th rows are the same as those in the 3rd, 2nd and 1st respectively.

Table 8. *Bricks in different parts of the citi—second layer (after Karavinda).*

Parts of the *citi*	Brick type			Total
	B_1	B_2	B_4	
Head, with part of juncture with body	2	2		4
Body, with part of junctures with head and tail	24	32		56
Wings		8	112	120
Tail, with part of juncture with body	10	10		20
Total	36	52	112	200

In the tail, 3 B_2s are placed on either side as before. In the second row, south-north, the remaining space is covered by 2 B_1s in the middle and 2 B_2s on either side, and in the last row at the end by 6 B_1s as in Fig. 22(a). The total number of bricks and their types, as per Karavinda's description, are given in Table 8.

KĀTYĀYANA-ŚULBASŪTRA

CHAPTER 1

DRAWING OF EAST-WEST LINE, CONSTRUCTION OF SQUARES AND FIXING THE PLACES OF THE *ĀHAVANĪYA*, *GĀRHAPATYA*, *DAKṢIṆĀGNI* AND *UTKARA* ALTARS

The *Kātyāyana-śulbasūtra*, in six chapters, is essentially a geometrical work containing the main principles of geometry and some problems involved in altar construction. Kātyāyana has made some reference to different *vedis* and *agnis* without any details of their construction with bricks and tried to explain geometrical results as such. In this chapter he has dealt with the method of drawing east-west and north-south lines, the construction of squares and the determination of the relative positions of *āhavanīya*, *gārhapatya*, *dakṣiṇāgni* and *utkara altars*.

DRAWING OF EAST-WEST AND THE NORTH-SOUTH LINES

1.2. Let O be the pole, and a circle EPW be drawn with a cord of length equal to OP.

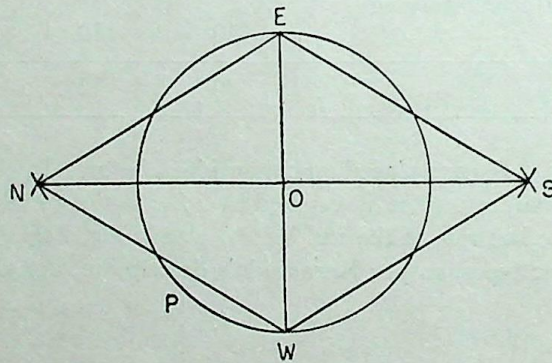



Fig. 1.

Let E and W be the eastern and western shadow points on the equinoctial day of the pole fixed at O (Fig. 1). Apte[a] suggests that the actual east-west line was determined by the shadow of the pole on the equinox day and verified by the rising and setting points of the star Kṛttikā. Then EW is in east-west or *prācī* line. Two knots are given at the two ends of a cord which is double of the original cord and are fastened at the poles at E and W. The cord is then stretched towards north by its middle point and a mark N is given at it. This is the north point. Similarly south

[a] Apte, 1-16

point S is obtained. Then NS, gives the north-south line. In the *Śulbasūtras* the east-west line has always been drawn first presumably because of the importance attached to this direction.

CONSTRUCTION OF A SQUARE OR A RECTANGLE

1.3 This gives a general method of construction of a square or a rectangle. In a given cord marks are given for *śroṇi, aṃsa* and *nirañchana* points. Two knots are fixed at the two ends of the cord; then fixing the two ends of the cord to the poles at the two ends of the east-west line, the cord is drawn by the *nirañchana* mark on either side of the line. By interchanging the knots at the two ends, the operation is repeated. Further details as to the length of the cord corresponding to a given distance between the two poles (the length of the altar) and where the *nirañchana* mark is to be given are discussed in the subsequent rules.

1.4-1.9. Rules 1.4 and 1.5 give direction for determining the *nirañchana* points and are used for the construction of square and rectangles.

First cord. Let AB, the given measure be a, BC, the added length a, and D, the *nirañchana* mark (Fig. 2(a)) so that

$$BD = \frac{BC}{4} = \frac{a}{4}.$$

By definition, $AD = \text{the diagonal} = \frac{5a}{4}$

and $DC = \text{the breadth} = \frac{3a}{4}$

Clearly, $AD^2 - DC^2 = \left(\frac{5a}{4}\right)^2 - \left(\frac{3a}{4}\right)^2 = a^2$

This is the expression for a right triangle ADC, of which AD is the diagonal *(akṣṇayā)*, CD the breadth *(tiryaṅmānī)* and AC, the given measure for *prāci*.

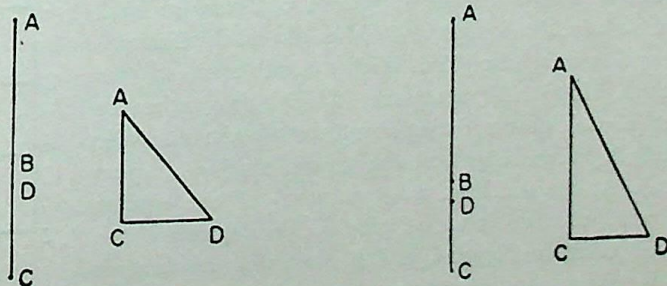



Fig. 2

(a) First cord. (b) Second cord.

Second cord. Let AB, the given measure be a, BC, the added length, $\frac{a}{2}$, and D, be the *nirañchana* mark (Fig. 2(b)) so that

$$BD = \frac{1}{6} \cdot \frac{a}{2} = \frac{a}{12},\ AD = \frac{13a}{12},\ \text{and } CD = \frac{5a}{12}.$$

This satisfies the square relation: $a^2 + \left(\frac{5a}{12}\right)^2 = \left(\frac{13}{12}a\right)^2$ of the right triangle.

The term *tiryaṅmānī* literally means 'transverse' or 'oblique' measure. In the *Śulbasūtra*, however, it has been used to signify the 'breadth' or 'shorter side' of a rectangle. Mahīdhara says: *nirañchanenākarṣaṇe kṛte śroṇyaṃsa parichedikā yā rajjuḥ sā tiryaṅmānī.*

After finding the perpendicular lines to the east-west line with the help of any of the above cords, poles are fixed upon the perpendicular lines at a distance equal to half the measure from the *prācī* to obtain the square. For rectangle, poles are fixed at a distance equal to half the value prescribed in the text.

The *śakaṭamukha* means a figure resembling the fore-part of a cart and represents an isosceles triangle. It is also constructed out of square or rectangle (*BŚl.* 2.7-2.8). The *prāgvaṃśa* is a rectangle (*BŚl.* 4.1), the *śālā* a rectangle (Mahīdhara) and the *sada* also a rectangle (*BŚl.* 4.4). In the construction of these altars the north-south line is considered the reference line. For construction, decrease and increase of measures of altars, Kātyāyana followed the direction of older *śāstras*.

Relative Positions of the *Gārhapatya*, *Āhavanīya*, *Dakṣiṇāgni* and *Utkara*

1.9-1.10. Let A and G be the positions of *āhavanīya* and *gārhapatya* fire-altars. As explained by Mahīdhara, the distance AG is to be reduced by one-third. With a cord equal to this reduced length, that is AB, a square $EFGD$ is drawn in the eastern part (Fig. 3), that is, from point A westward,: *pūrvārdhe āhavanīyamadhyāt paścimabhāge samacaturasramuktavidhinā kāryam* (Mahīdhara). At the southern *śroṇi* point D of this square *(dakṣiṇaśroṇyam)* the fire is to be placed. To determine the place of *utkara*, a similar figure *UJKL* is drawn in the western part, that is, from the *gārhapatya* point G towards east: *paścimārdhe gārhapatyasya madhyāt pūrvabhāge*. Then U, the northern *aṃsa* point of the square is the *utkara*.

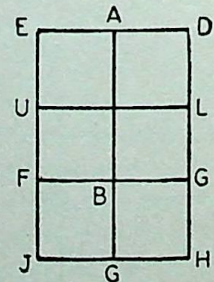



Fig. 3.

Chatper 2

UNITS OF MEASURES, *PAITṚKĪ VEDI*, MEASURES FOR DIAGONAL, THEOREM OF SQUARE, COMBINATION OF SQUARES.

2.1. *Units of measures.* Units like *iṣā, akṣa, yuga* and *śamyā* have been expressed here in *aṅgulas*. This has been discussed under *Bśl.* 1.3.

2.3. *Paitṛkī vedi.* The *paitṛkī vedi* has been dealt with by Baudhāyana (*Bśl.* 3.11).

2.3-2.6. *Measures for the diagonal of a rectangle.* Kātyāyana has considered a particular measure for a square as *karaṇi*, so that its diagonal becomes *tatkaraṇi* or *dvikaraṇi*, (*tat kṣetraṃ dvaiguṇyādi kriyati 'nayā sā tatkaraṇi*—Mahīdhara), for square on the diagonal is twice the original square. Likewise, the diagonal of a rectangle having sides as *prāśvamāni* and *tiryaṅmāni* is known as *akṣṇayā*. With the help of these technical terms Kātyāyana has expressed the measures for the diagonal of a rectangle in the following two cases :

$$1^2 + 3^2 = (\sqrt{10})^2$$

and

$$2^2 + 6^2 = (\sqrt{40})^2$$

Other measures *yuga* and *śamyā* have been defined in *Kśl.* 2.1.

2.7 *Theorem of square.* Kātyāyana here enunciates the general theorem of square on the diagonal of a rectangle in the same language as did Baudhāyana (*Bśl.* 1.12) and Āpastamba (*Aśl.* 1.4).

At the end of the enunciation, he remarks, *iti kṣetrajñānam.* The term *kṣetra* has been translated as 'area' by Thibaut[a] and 'figure' by Datta.[b] In the *śulbasūtra*, the area is technically expressed by *bhūmi* (*Bśl.* 1.6 and 1.9) and not *kṣetra*. Hence *iti kṣetrajñānam* means 'this is the knowledge of plane figures'.

2.8-2.9. *Combination of two equal squares. Dvikaraṇi* has been defined here as $\sqrt{2}\, a$, where a is the measure. This is actually a method of combination of two equal squares each of side a into one of $\sqrt{2}a$. *Tritiyākaraṇi* has been defined as *navabhāgastraya* of *tṛkaraṇi* :

i.e. if *tṛkaraṇi* $= \sqrt{3}a$,

then *tṛtīyākaraṇi* $= \dfrac{3.\ \sqrt{3}a}{9} = \dfrac{1}{\sqrt{3}}\, a$,

where a is the measure.

Kātyāyana's rule is essentially the same as that of Baudhāyana (*Bśl.* 2.12).

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[a] Thibaut (2), 233-34.

[b] Datta (2), 108.

2.10-2.12. *Construction of an isosceles trapezium.* After explaining the meaning of *dvikaraṇi, tṛkaraṇi,* and *tṛtiyākaraṇi* of a given measure Kātyāyana gives the method of construction of the *sautrāmaṇiki vedi,* which is an isosceles trapezium having face $= \frac{24}{\sqrt{3}}$, base $= \frac{30}{\sqrt{3}}$ and altitude $= \frac{36}{\sqrt{3}}$ *prakramas* (vide *Bśl.* 3.12).

2.13. *Combination of two squares.* Kātyāyana prescribes the same method of Baudhāyana for the combination of two different squares into a square (*Bśl.* 2.1.).

Chapter 3

DIFFERENCE OF TWO SQUARES, TRANSFORMATION OF A RECTANGLE INTO A SQUARE AND A SQUARE INTO A RECTANGLE, AREAS OF FIGURES, PROBLEM OF CIRCLING A SQUARE AND QUADRATURE OF THE CIRCLE.

3.1-.34. The rule 3.1 deals with the construction of a square equal to the difference of two squares, 3.2-3.3 the transformation of a rectangle into a square and 3.4 transformation of a square into a rectangle. These rules have been given by Baudhāyana (*Bśl.* 2.2, 2.5 and 3.4 respectively). The transformation of a rectangle into a square, when it is very large, is specially discussed by Kātyāyana, as has also been done under *Bśl* 2.5.

3.5-3.10. These concern the areas of squares and rectangles and are essentially the same as those of Āpastamba (*Aśl.* 3.4-3.10)

3.11-3.12. For circling a ṣquare and the quadrature of the circle,Kātyāyana gives the same rules as those by Baudhāyana (*Bśl.* 2.9-2.11) and Āpastamba (*Āśl.* 3.2, 3.3).

Chapter 4

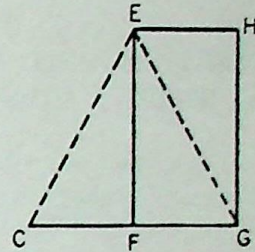
CONSTRUCTION OF *DROṆACIT*, TRIANGLE, RHOMBUS, TRANSFORMATION OF TRIANGLE AND RHOMBUS INTO A SQUARE

4.1-4.2. *Construction of droṇacit.* Kātyāyana discusses here the methods of drawing different squares required for the construction of *droṇacit.* First a square of area $7\frac{1}{2}$ sq. *pu.* is constructed and divided into 100 small squares by drawing ten parallel lines horizontally and ten vertically. Then small squares from one side are separated out and changed into a small square by the method of combination of squares *(samāsa-vidhi),* discussed in *Kśl.* 2.8 and 2.9. The remaining 90 small squares are likewise transformed into a single square. The former square is joined to the latter like a stalk. In the case of a circular *droṇacit,* the two squares mentioned above are

to be transformed into two circles and joined together (Mahīdhara). Kātyāyana's rule is basically different from that of Baudhāyana (*Bśl.* 17.1.-18) and Āpastamba (*Āśl.* 13.4-5) and appears mathematically more sound.

4.3-4.4. *Construction of triangle and rhombus.* These two rules are the same as those of Baudhāyana (*Bśl.* 2.7-2.8).

Fig. 4. Transformation of a triangle into a square.

4.5. *Transformation of an isosceles triangle into a square.* For transformation of an isosceles triangle into a square, the isosceles triangle *ECG* is divided by the *prāci* line *EF* (Fig. 4). Now tr. *ECF* is transferred to the other side so that tr. *EGH* is now its new position. Thus tr. *ECG* is transformed into the rectangle *EFGH*. This rectangle is changed into a square by the *sūtra Kśl.* 3.2. It has also been discussed by Āpastamba (*Āśl.* 12.4-12.8).

4.6. *Transformation of a rhombus into a square.* For transforming a rhombus *ENFS* into a square, *EF* and *NS*, the east-west and north-south lines are joined (Fig. 5). The isosceles triangle *NFS* is clearly sub-divided into two triangles *NOF* and *SOF*. These are now transferred and after invertion placed in their positions as *AEN* and *BES*. Thus the rhombus *ENFS* is transformed into the rectangle *ANSB*. This rectangle is transformed into a square by the *sūtra Kśl.* 3.2.

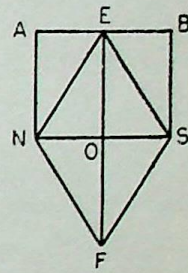



Fig. 5 Transformation of a rhombus into a rectangle.

4.7. *Transformation of a triangle into a square.* Kātyāyana has hinted for the first time at a method of transforming into a square a triangle other than the isosceles. The rule is, however, incomplete. According to commentator Mahīdhara, *ekakarṇa* means *tulyakarṇa*, i.e. a figure having equal angles and *dvikarṇa nānāvidhakarṇa*, i.e. a figure of unequal angles. Whether by *nānāvidhakarṇa* Mahīdhara meant an irregular pentagon cannot be definitely said. *Śulbakāras* were well acquainted with the method of converting an isosceles triangle into a square. Possibly they had also the knowledge of transformation of a pentagon of equal angles into a square by joining the angular points, dividing it into several isosceles triangles, and then joining them up into squares by the rule taught before. Kātyāyana has advised to break up *pañcakarṇas* of *dvikarṇa* variety into a square. But there is no such method known to the *śulbakāras* by which an irregular pentagon can be broken up into squares. Kātyāyana's pentagon *ABCDE* is of the type of *haṃsamukhi* brick (Fig. 6), in which $BF = FC = EH$ and $AB = HF = DC = \frac{BF}{2}$. Description of this type of pentagonal *haṃsamukhi* bricks is given by

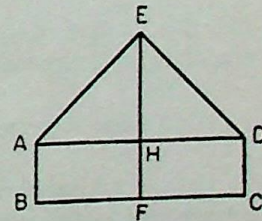



Fig. 6.

Baudhāyana (*Bśl.* 10.10). A pentagon of this type can be broken up into two or three squares, which again can be combined into a single square.

Chapters 5 and 6

ENLARGED UNIT, CONSTRUCTION OF A SQUARE EQUAL TO *N* TIMES A GIVEN SQUARE AND *EKĀDAŚINĪ* FIRE-ALTAR.

The whole of chapter 5 and the first five *sūtras* of chapter 6 are devoted to the discussion of enlarged unit required for measuring the areas of fire-altars from $8\frac{1}{2}$ sq. *puruṣas* to $101\frac{1}{2}$ sq. *puruṣas*. Most of these results agree with those of Baudhāyana and have been discussed under *Bśl.* 5.1-5.6. In *sūtra* 6.2, Kātyāyana says that if s be the maximum enlarged unit in a *prakrama* for 101 fold fire-altar, then s^2 equals $14\frac{3}{7}$ sq. *prakramas*. In the next *sūtras* he has pointed out that at each successive constuction the value of the *prakrama* is to be increased by one seventh of the increased area,

$$\text{i.e. } s^2 = 1 + \frac{p}{7} \;\ldots\ldots\; (1)$$

or $7s^2 = 7 + p$, where p is the increased area.

For the construction of 101 fold fire-altar the total increment from the 7 fold one is 94. Putting $a = 94$.

$$7s^2 = 7 + 94 = 101,$$

$$\text{then } s^2 = \frac{101}{7} = 14\frac{3}{7} \;\ldots\ldots\; (2)$$

But the formula (1) does not appear to be correct (vide *Bśl.* 5.1-5.6); it should be $s^2 = 1 + \frac{p}{7\frac{1}{2}}$, since the enlargement in area starts from the normal 7 fold fire-altar, i.e. $7\frac{1}{2}$ sq. *puruṣas*. It may be that Kātyāyana simplified the rule for construction of 101 fold fire-altar.

Datta[a] has suggested another rational of the formula (2) as follows.

In the falcon-shaped fire-altar (second plan), the problem of proportionate enlargement is equivalent to the solution of the following quadratic equation:

$$4s^2 + 2s\left(s + \frac{1}{5}\right) + s\left(s + \frac{1}{10}\right) = 7\frac{1}{2} + p,$$

$$\text{or, } 7s^2 + \frac{1}{2}s = 7\frac{1}{2} + p,$$

a Datta (2), 166-168.

$$\text{or, } \left(7s + \frac{1}{4}\right)^2 = \frac{841}{16} + 7p,$$

$$\text{or, } s = \frac{1}{28}\left(\sqrt{841 + 112p} - 1\right)$$

When $p = 94$,

$$s = \frac{1}{28}\left(\sqrt{11369} - 1\right) \text{ or, } s^2 = \frac{1}{784}\left(11370 - 2\sqrt{11369}\right),$$

$$\text{or, } s^2 = \frac{1}{784}\left(11156 + \frac{79}{106}\right), \text{ when } \sqrt{11369} = 106 + \frac{133}{212} \text{ approx.}$$

$$\text{or, } s^2 = 14 + \frac{19159}{83104}$$

$$= 14 + \frac{3}{13\frac{245}{19159}} = 14 + \frac{3}{13} \text{ approx.}$$

It is nearly equal to Kātyāyana's value, $s^2 = 14\frac{3}{7}$

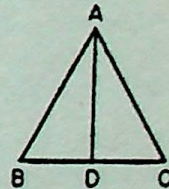
6.7. *Construction of a square equal to n times the given square.* This method undoubtedly hints at the construction of a square which is equivalent to n times a given square. Let n number of equal squares each of side a are to be combined. *Śulbakāras* used isosceles triangles for different constructions. Here also Kātyāyana possibly considered an isosceles triangle ABC, in which

$$BC = (n - 1)\,a,$$
$$AB + AC = (n + 1)\,a,$$

Since $BD = DC,\ AB = AC,$

$$BD = \frac{n-1}{2}\,a, \text{ and } AB = \frac{n+1}{2}\,a,$$

Fig. 7.

According to this rule, the altitude AD will produce the sum of n equal squares.

$$\text{Now } AD^2 = AB^2 - BD^2$$
$$= \left(\frac{n+1}{2}a\right)^2 - \left(\frac{n-1}{2}a\right)^2$$
$$= na^2$$

6.8-6.13. Construction of a fire-altar with enlarged areas was usually carried out by fixing the distance between the two poles *(yupas)* of *ekādaśini*. This distance is known as *prakrama*. The length of *prakrama* varies in the case of the enlarged fire-altar. There are various opinions on this point by ancient masters. This has been discussed under *Bśl*. 4.12-4.14.

MĀNAVA-ŚULBASŪTRA

The *Mānava-śulbasūtra*, in 16 chapters, is a mere compilation, and its value as a technical text appears to be of dubious nature. In most places it is corrupt, and the same topics are discussed in different places. The materials on *gārhapatya*, for instance are dispersed in chapters 1, 6, 9, 13, on *caturaśraśyenacit* in chapters 4, 5, 6 and 13, on *dhiṣṇyas* in chapters 6, 9 and 13 etc. It is full of paraphernelia about worship hardly of any consequence to altar construction. The arrangement is unsystematic. The text therefore bears no comparison with the three other *śulba* texts already commented upon.

CHAPTER 1

DETERMINATION OF EAST-WEST LINE, CONSTRUCTION OF *DĀRŚIKĪ VEDI*, SIZE AND RELATIVE PLACES OF *GĀRHAPATYA, ĀHAVANĪYA DAKṢIṆĀGNI, UTKARA* AND GENERAL RULE FOR DRAWING A SQUARE.

1.2-1.3. *East-west line. Sūtras* 1.2 and 1.3 direct the fixation of the east-west line of the altar according to cardinal points. The rule is incomplete.

1.4-1.6. *Dārśiki vedi.* The *dārśiki vedi* is in the shape of an isosceles trapezium having face 48 *aṅg.*, base 64 *aṅg.*, and altitude 96 *aṅg.* (*Fśl.* 3.6-3.7, *Aśl.* 4.5-4.6). The given verse is not very clear in describing the method of construction required for the purpose. Here the *prāci* is of 4 *aratnis* (96 *aṅg*) and the cord of 6 *aratnis* (144 *aṅg*) out of which a right triangle of sides 40, 96 and 104 is formed. By using this right triangle, the isosceles trapezium required for the *dārśikī vedi* is constructed. How the sides of the isosceles trapezium are cut off has been described by Baudhāyana and Āpastamba.

1.7-1.10. *Gārhapatya, āhavaniya, dakṣiṇāgni and utkara.* Mānava describes *āhavaniya* as a square of one sq. *aratni, gārhapatya* and *dakṣiṇāgni* as circle and semi-circle of the same area. His incomplete method of circling a square appears to follow that of Baudhāyana, Āpastamba and Kātyāyana (*Bśl.* 2.9, *Aśl.* 3.2 and *Kśl.* 3.11). The method of finding the relative positions of these fires and of *dakṣiṇāgni* also differs from that given by other *śulbakāras*.

1.11-1.12. *Construction of a square.* The rule gives a general method of construction of a square. If a be the original length of the cord, and a, the increased length of the cord, the *nirañchana* mark is given at a point dividing the total length $2a$ into two parts, $\frac{5}{4}a$ and $\frac{3}{4}a$. This satisfies the relation,

$$a^2 + \left(\frac{3}{4}a\right)^2 = \left(\frac{5}{4}a\right)^2.$$

By using this relation which satisfies the condition of a right-angled triangle, the required circle is drawn. This method resembles that of Baudhāyana (*Bśl.* 1.4-1.5).

Chapter 2

UNITS OF CHARIOT, CONSTRUCTION OF *PAŚUBANDHA, PĀŚUKĪ, MĀRUTĪ, VARUṆA* AND *PAITṚKĪ VEDIS*

2.1-2.3. *Units, paśubandha vedi.* 1 *iṣā* = 188 *aṅg.*, 1 *akṣa* = 104 *aṅg.*, and 1 *yuga* = 86 *aṅg.* (*vide Bśl.* 1.3). The method of construction of *paśubandha* altar is not very clear.

2.4. *Pāśukī vedi.* The method is incomplete and may be reconstructed as follows. The *pāśukī vedi* is an isosceles trapezium having face 3 *aratnis*, base 4 *aratnis*, and altitude 6 *aratnis*. A cord AC (9 *aratnis* long) is used for its construction. Marks are given on it at B, N, S, M for obtaining *prācī, nirañchana, śroṇi* and *aṃsa* points, such that AB equals 6 *aratnis*, AN $6\frac{1}{2}$ *aratnis*, BN, NS, SM each $\frac{1}{2}$ *aratni* and CN $2\frac{1}{2}$ *aratnis*. This satisfies the relation $AB^2 + CN^2 = AN^2$ or, $AC^2 + CN^2 = AN^2$, when the ends A and C are fixed on the east-west line, i.e. $6^2 + (2\frac{1}{2})^2 = (6\frac{1}{2})^2$ holds. This is used for the construction of the isosceles trapezium $DEFG$ (Fig. 1), the form of the *pāśukī vedi*.

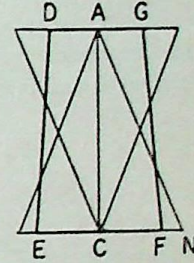



Fig. 1.

2.5. *Mārutī and varuṇa vedi.* The *mārutī vedi* is also an isosceles trapezium having face 3 *aratnis*, base 4 *aratnis* and altitude 6 *aratnis*. A cord of length 12 *aratnis* is taken and the *nirañchana* mark fixed at $7\frac{1}{2}$ *aratnis* ($\frac{1}{2} + 2 + 2 + 1\frac{1}{2} + 1\frac{1}{2} = 7\frac{1}{2}$) from one end; the remaining cord measures $4\frac{1}{2}$ *aratnis* ($\frac{1}{2} + 1\frac{1}{2} + 1\frac{1}{2} + 1 = 4\frac{1}{2}$). This satisfies the relation $6^2 + (4\frac{1}{2})^2 = (7\frac{1}{2})^2$, which appears to have been used for the construction of the altar. A similar tedious technique is applied for the construction of the *varuṇa vedi*,[a] which is an isosceles trapezium having face $1\frac{1}{2}$ *aratnis*, base 2 *aratnis*, and altitude 6 *aratnis*.

2.6-2.7. *Paitṛkī vedi.* This appears to be a rhombus in shape, and pointing towards the cardinal directions. Van Gelder quoted Śivadāsa who prescribed a cord of 8 *aratnis* with marks at 4 *aratnis* and $5\frac{2}{3}$ *aratnis*. This is obviously wrong, as these markings do not lead to the relationship for a right triangle. Simply a cord of 10 *aratnis* long is taken up and two ends are tied to the *prācī* points E and W, where EW equals $5\frac{1}{2}$ *aratnis*. The cord is then stretched by the middle point on either side, fixing the points G and H. Hence $EHWG$ is the required *paitṛkī vedi.*

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a Majumdsr (2).

Chapter 3

POSITIONS OF *PRĀGVAṂŚA, SADAS,* AND *HAVIRDHĀNA*, RELATIVE TO *MAHĀVEDI*

3.1-3.4. The distances for finding the positions of *prāgvaṃśa, sadas,* and *havirdhāna* relative to *mahāvedi* are given here. These values differ from those of Baudhāyana (*Bśl.* 4.1-4.11), although the dimensions of the *mahavedi* remain the same in both the texts.

3.5. The relation is : $3^2 + 1^2 = 10$. This has been used by Kātyāyana in *Kśl.* 2.4.

3.6-3.9. The *sada* is given as a rectangle, 27×9. Out of a rectangular area of breadth 10 *aṅgulas* in the eastern side of the *mahāvedi,* the rectangle of breadth $2\frac{1}{2}$ *aṅg.* from east is for *śikhaṇḍinī vedi* (*vide Bśl.* 4.12), and the next rectangle of $7\frac{1}{2}$ *aṅg.* is known as *devyavedi*. The description of *kaukilī vedi* is not clear. According to Gelder, this represents an isosceles trapezium having *prāci* equal to 12 *prakramas,* base10 *prakramas* and face 8 *prakramas*.

Chapters 4 and 5

UNITS OF MEASURES AND WEIGHTS, BRICKS

4.1-4.6. The six rules provide a table of units of measure.

4.7-4.8. Sizes of bricks and different layers are generally stated.

Chapter 5 describes a method of measuring areas in a square *śyena (caturaśra-śyenacit)*.

Two bamboo rods are taken, one measuring 120 *aṅg.* (one *puruṣa*) in length, the other 144 *aṅg.* In the second bamboo rod marks are given at a distance of 120 *aṅg.,* 132 *aṅg.* and 144 *aṅg.* from one end. Two middle marks are given in these two rods at a distance of 60 *aṅg.* from the same ends. Then a *pañcāṅgī* cord is formed in the following way (*vide Mśl* 13.15). A cord *AB* of length 2 *puruṣas* (240 *aṅg*) is taken and three marks are given, one at the middle of the cord *C* and one each at the middle of the two halves, i.e. at *D* and *E.* (Fig. 2). The cord is fixed by two poles at its eastern end *A* and the western end *B*; poles are likewise fixed at *C, D,* and *E.* The two bamboo rods are then stretched towards south from *D* and *E* respectively so as to meet at *F,* 120 *aṅg* from the end of each. The first bamboo rod is held over *CF* so as to obtain *G* at 120 *aṅg* from *C.* Now the second bamboo rod is stretched from pole *A* towards south and the first rod from *G* towards east so as to meet at *H,* 120 *aṅg* from the end of each rod. *H* is the south-eastern corner of the

ātmā. Likewise, the north-eastern corner *I* and the two western corners *J* and *K* of the square body are fixed. The area of the body is thus 240^2 sq. *aṅg* or 4 sq. *pu.*
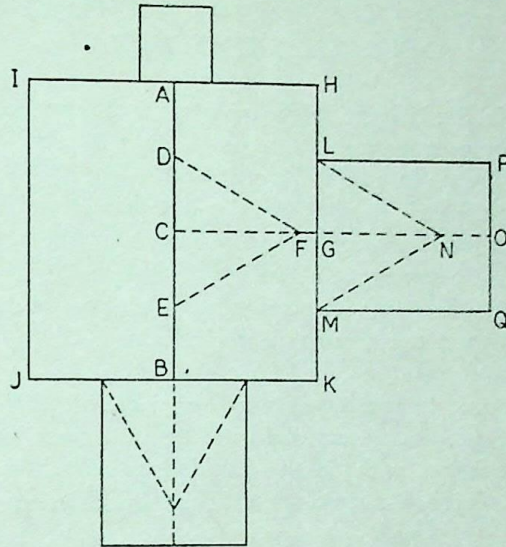
Fig. 2. Construction of a *caturaśraśyenacit.*

To construct the northern wing poles are fixed at *L* and *M,* the middle points of the two halves of the southern side *HK.* By stretching the two bamboo rods from *L* and *M* towards south the point *N* where they meet at a distance of 120 *aṅg* from the end is determined. The second bamboo rod is now held over *GN* and the point *O* 144 *aṅg* from *G* is obtained. Then by stretching the second rod from *L* and the first rod from *O* the point *P* is fixed and likewise the point *Q,* so that the rectangle *LPQM* constitutes the southern wing. Likewise the northern wing is formed. The area of each wing measures 120 $\times$ 144 sq. *aṅg* or $1\frac{1}{5}$ sq. *pu* and that of two wings $2\frac{2}{5}$ sq. *pu.*

To obtain the tail, one has to proceed in the same manner as for the wing; but the mark with the second bamboo rod stretched from *B* westwards should be given at a distance of 132 *aṅg.* In other words, a rectangle 120 $\times$ 132 sq. *aṅg* or $1\frac{1}{10}$ sq. *pu* is to be formed.

For the head a square 60 $\times$ 60 sq. *aṅg* (according to Śivadāsa, a rectangle of 60 $\times$ 75 sq. *aṅg*) is to be formed at the middle of the eastern side.

In this construction, the body, the two wings and the tail $(4 + 2\frac{2}{5} + 1\frac{1}{10})$ account for $7\frac{1}{2}$ sq. *pu,* with the head needing an additional area and thus deviating from the traditional area of a fire-altar of this type. We have seen that Baudhāyana did not provide his square *śyenacit* with a head and strictly restricted himself to the area of $7\frac{1}{2}$ sq. *pu.*

Chapter 6

GĀRHAPATYA, ĀGNIDHRĪYA, BRĀHMAṆĀCCHAṂŚA, MĀRJĀLĪYA AND CATURAŚRAŚYENACIT.

6.1-6.9. *Gārhapatyaciti*. Six kinds of bricks are used for the construction of *gārhapatya* fire-altar. Their measurements are: 12 *aṅg* × 24 *aṅg*.; 24 *aṅg* × 24 *aṅg*.; 12 *aṅg*. × 12 *aṅg*.; 12 *aṅg* × 6 *aṅg*.; 12 *aṅg*. × 18 *aṅg*.; and 30 *aṅg*. × 30 *aṅg*. The height of these bricks is 6 *aṅg*.; the heights of *nākasad* and *pañcacodā* are half of these, but whether the heights of *ṛtavyā* and *vaiśvadevī* bricks are also half is not clear. Mānava gives no idea as to how to arrange the bricks in the first and second layers (compare with *MŚl*. 13.6-13.13). The *sūtra* 6.7 is so vague and inadequate that no attempt has been made to reconstruct the arrangement of bricks.

6.10. *Āgnidhrīya, hotrīya, brāhmaṇācchaṃśa and mārjālīya*. A similar description of *āgnidhrīya* square of side 36 *aṅg*. divided into 9 equal parts with a stone being placed at the centre is met with in the *Baudhāyana-śulba*. The descriptions of *hotrīya, mārjālīya* and *brāhmaṇācchaṃśa* are different in different places (vide *Mśl*. 13.23-13.29).

6.11-6.15. *Caturaśraśyenacit*. The placement of bricks in two layers of *caturaśraśyenacit* is hinted at. Rectangular (18 *aṅg*×12 *aṅg*) and square bricks (12 *aṅg* × 12 *aṅg*., also 30 × 30 sq. *aṅg*) are used for this purpose. There is no mention of the total number of bricks required for each layer. What can be ascertained from the rules is that the first layer contains 98 *adhyardhā* (18 × 12) bricks (40 in the eastern and western sides of the *ātmā*, 48 in the eastern and western sides of the two wings and 10 in the head) and the second layer 72 *adhyardhās* (40 in the southern and northern sides of the *ātmā*, 22 on either side of the tail and 10 in the head). The remaining space is to be filled by square bricks. Van Gelder suggested 80 square bricks of size. 30 × 30 sq *ang*. and 128 square bricks of size 12 × 12 sq. *ang*. making the total for the first layer 306.[a] For the second layer the total number of bricks was likewise shown to be 269. Several other alternatives are possible, but that would be a futile exercise.

The *sūtra* 6.14 lays down how to perform worships of three and six days.

Chapters 7 and 8

These two chapters describe the construction of *suparṇaciti*, not found in earlier *śulba* literature. In this structure various bricks such as *viśvajyoti, ṛtavyā, svayamātṛ, apasyā, prāṇabhṛt, vaiśvadevī, vāyavyā, chanda, virāja, vikarṇī* have been used. The description is mostly of a general nature.

[a] Van Gelder, 294

Chapter 9

AREAS OF *GĀRHAPATYA, DHIṢṆYAS* AND PLACING OF BRICKS IN DIFFERENT *YAJÑAS*

The *gārhapatya* is a square *citi* of 9216 sq. *aṅgulas*. The square *gārhapatya* has side 96 *aṅg.* There are eight *dhiṣṇyas,* namely, *āgnidhriya, mārjālīya,* and six others within the *sadas,* viz. *hotṛī, maitrāvaruṇa* (or *praśāstrī*), *brāhmaṇācchaṃśin, potri, neṣṭṛ* and *acchāvaka.* Each *dhiṣṇa* has an area of 1296 sq. *aṅgulas;* a square *dhiṣṇa* is of side 36 *aṅg.* The fire-altar is 111600 sq. *aṅgulas* in area.

Now, 111600 sq. *aṅg.* = $7\frac{3}{4}$ sq. *pu.* An area of $\frac{1}{4}$ sq. *pu.* for the head is added to original $7\frac{1}{2}$ sq. *pu. agni.* Here the break-up is as follows (for measures vide *Mśl.* 11.2-11.8).

Atman = 400 sq. *padas* = 20 *padas* × 20 *padas*
= 2 *pu.* × 2 *pu.* = 4 sq. *pu.*

Each wing = 120 sq. *padas* = 10 *padas* × 12 *padas*
$= 1\ pu. \times \frac{12}{10}\ pu. = \frac{6}{5}$ sq. *pu.*

Tail = 110 sq. *padas* = 10 *padas* × 11 *padas*
$= 1\ pu. \times \frac{11}{10}\ pu. = \frac{11}{10}$ sq. *pu.*

Head = 25 sq. *padas* = 5 *padas* × 5 *padas*
$= \frac{1}{2}\ pu. \times \frac{1}{2}\ pu. = \frac{1}{4}$ sq. *pu.*

$$\text{Total area} = 4 + 2.\frac{6}{5} + \frac{11}{10} + \frac{1}{4} = 7\frac{3}{4} \text{ sq. } pu.$$

The placement of bricks has been described in a general way.

Chapter 10

THE *ŚULBAVID, ŚAṄKU,* ROPE, MEASUREMENT OF VOLUME, PROPERTIES OF RIGHT-ANGLED TRIANGLE

The qualifications of *śulbabid* and the nature of *śaṅku* and rope are described. The *śulbabid* is one who is versed in geometry (measurement of areas), calculations, and altar construction and who takes up as a profession the measurement of areas.

The ground for the construction of al'ars should be plane, the *śaṅku* or poles must be straight and the cord smooth.

For the volume measure (*Mśl.* 10.9) length, breadth and height are multiplied.

In a right-angled triangle, $a^2+b^2=c^2$ where a = length, b = breadth and c = hypotenuse (*Mśl.* 10.10).

Chapter 11

UNITS OF MEASUREMENT, CIRCLING A SQUARE, AREAS OF PLANE FIGURES, VALUE OF π, QUADRATURE OF THE CIRCLE, USE OF *PAÑCĀṄGĪ* CORD, MEASURES FOR DIAGONAL OF A RECTANGLE

11.1-11.8. *Units of measure.* The units of human measure become short or long depending on the stature of the sacrificer. However, the table runs as follows : 1 *yava*=6 mastard seeds; 1 mastard seed=6 cords of hair; 1 *aratni*=2 *prādeśas;* 1 *prakrama*=1 *aratni* or 2 *prādeśas* (in *citi* measure); 1 *puruṣa*=120 *aṅgulas*=5 *aratnis* or 10 *padas;* 1 *yuga*=86 *aṅgulas;* 1 *akṣa*=104 *aṅgulas;* the *ratha* measures are according to the prescription of the text.

11.9-11.10. *Circling a square.* The method of circling a square described by Mānava in *Mśl.* 1.8*a* is repeated. Here the word, *viṣkambha* meaning 'diagonal' has been used; it should be *viṣkambhārdha* meaning 'radius'. This rule has been explained by Baudhāyana (*Bśl.* 2.9).

11.11-11.12. *Areas of figures.* If d be diagonal of a quare of side a, then $d^2 = 2a^2$; that is, the square on the diagonal produces twice the area of the original square; similarly $D^2 = 2d^2 = 4a^2$, where D is the diagonal of the square drawn on the diagonal of the original square of side a; and so on. The area of a rectangle with breadth 2 *pu.* and length 8 *pu* is 16 sq. *pu.* (*Mśl.* 11.18).

11.13. *Value of* π. If c be the circumference, d the diameter of a circle,

$$c = \frac{d}{5} + 3d = 3{\cdot}2\ d$$

$$\text{or} \quad \frac{c}{d} = 3.2.$$

Baudhāyana has also given a similar approximate value of π as 3 (*Bśl.* 4.15).

11.14-11.16. *Quadrature of the circle.* Possibly these are not problems of quadrature of the circle. Ordinary squares are drawn without any mathematical significance.

11.17. *Properties of right triangle.* The relations $3^2+4^2=5^2$, and $(3n)^2 + (4n)^2 = (5n)^2$, where n is any quantity, hold good for any right-angled triangle.

11.19-11.28. *Measurement of śroṇi and aṃsa points by pañcāṅgi cord.* How a cord with five marks *(pañcāṅgi)* is used to measure the western *(śroṇi)* and eastern corners *(aṃsa)* of *citis* other than *kaṅka* and *alaja* has been explained in a general way.

CHAPTER 12

DIAGONAL OF A RIGHT TRIANGLE

This chapter deals with the method of calculating the diagonal of a right triangle when its other sides are known. Sometimes out of three sides any two are known, when the third can be calculated. The length is known as measure or *pramāṇa* or *pārśvamānī*, breadth *veśeṣa* or *tiryaṅmānī*, and diagonal *akṣṇayā*.

(i) If length $= a$, breadth $= \frac{a}{2} - \frac{a}{12} = \frac{5}{12}\, a,$

diagonal produces a square equal to $\left(\frac{13}{12}\, a\right)^2$

(ii) If length $= \frac{a}{2}$, diagonal $= \frac{a}{2} + \frac{a}{24} = \frac{13}{24}\, a,$

then breadth produces a square equal to $\left(\frac{5}{24}\, a\right)^2$.

By applying this, two fold producer $(\sqrt{2}a)$, three fold producer $(\sqrt{3}a)$, twenty-one fold producer $(\sqrt{21}\, a)$ used for the *aśvamedha vedi*, and 101 fold producer are obtained.

This also justifies that

$$1^2 + (\sqrt{10})^2 = 11.$$

CHAPTER 13

CONSTRUCTION OF *SAUMIKĪ VEDI, GĀRHAPATYA* (BOTH SQUARE AND CIRCULAR), *CATURAŚRAŚYENA* OF ANOTHER TYPE, *ĀGNIDHRĪYA, HOTRĪYA, BRĀHMAṆĀCCHAṂŚA* AND *MĀRJĀLĪYA*

13.1-13.5 *Saumikī vedi.* Here the construction of *sautrāmaṇi*, *saumiki* and *paśubandha* fire-altars has been hinted at. The *saumiki* fire-altar is in the form of an isosceles

trapezium having face 8 $\sqrt{3}$, base 12 $\sqrt{3}$, and altitude 12 $\sqrt{3}$. This is meaningful (*ĀŚl.* 5.8-5.9),but the description regarding the other two is not very clear.

13.6-13.13. *Construction of gārhapatya vedi.* The *gārhapatya vedi* has two forms, e.g. square and circular, each covering an area of either one square *vyāyāma* or one square *puruṣa*. The fire-altar always contains 21 bricks in each layer. Mānava has given almost correct solution to each case.

For square *gārhapatya* of one square *vyāyāma,* he advises like Baudhāyana, the making of 21 bricks each of length $\frac{1}{3}$ of a *vyāyāma* and breadth $\frac{1}{7}$ of a *vyāyāma* (*Mśl.* 13.7). In the second layer directions of length and breadth are interchanged.

For square *gārhapatya* of one square *puruṣa,* he advises the whole area to be divided into 18 rectangular parts each of length $\frac{1}{3}$ of a *puruṣa* and breadth $\frac{1}{6}$ of a *puruṣa* (Mśl. 13.8.-13.9). Clearly, each brick measures 40 *aṅg* × 20 *aṅg*. Three corner bricks are replaced by those of size, 20 *aṅg* × 20 *aṅg*. thereby making the number of bricks 21. In the next layer the length and breadth are interchanged.

In the circular *gārhapatya* of one sq. *puruṣa,* a circle is drawn with a radius half a *puruṣa*. The altar is covered with 21 bricks by four types of bricks, the sizes of which are not given. This may be done by laying 12 square bricks of type I, 4 triangular bricks of type II of which one side is curved, and 4 bricks of type III, of which one side is curved and the other straight. One brick of type III is halved (type IV) to make the number 21. For the other layer the direction is only changed.

13.14-13.22. *Construction of caturaśraśyenacit.* This gives an incomplete description of another type of *caturaśraśyenacit* with *pañcamī* (24 *aṅg.* × 24 *aṅg.*), *adhyardhā* (36 *aṅg* × 24 *aṅg*) *pāda* (12 *aṅg.* × 12 *aṅg.*), and *ardhapāda* (6 *aṅg.* × 12 *aṅg.*) brick. Admi tting that the text is defective and the measures of bricks are uncertain, Gelder has given a tentative plan, but we shall make no such attempt. Like the previous type it has a square body, 2 rectangular wings, a rectangular tail, and a square head. There is no mention that the *citi* is constructed with 200 bricks.

13.23-13.29. *Construction of āgnidhrīya, hotrīya, brāmaṇācchaṃśa.* Compare with *Mśl.* chapters 6 and 9. *Dhiṣṇyās* are squares of size 36 *aṅg.* × 36 *aṅg.*, but the description is different at different places.

Chapter 14

VAKRAPAKṢA ŚYENA, KAṄKA AND *ALAJA*

14.1-14.6. *Parts of the body in śyena, alaja and kaṅka.* Measured with a square brick of size one-fourth of a *puruṣa,* the different parts of a *śyena, alaja* and *kaṅka* fire-altar comprise areas shown in Table 1.

Table 1. Areas of different parts of *śyena, alaja,* and *kaṅka fire-altar.*

	wings	head	*atman*	tail	feet	Total
śyena	75	4	26	15	—	120
alaja	75	2	26	17	—	120
kaṅka	75	7	26	8	4	120

The area of each fire-altar is given correctly as $120 \times \frac{1}{16}$ or $7\frac{1}{2}$ sq.*pu.*

14.7-14.20. *Layout of vakrapakṣaśyena.* For measuring *vakrapakṣaśyena* of $7\frac{1}{2}$ sq. *pu.* a cord with 12 parts has been used; each part is equal to 30 *aṅgulas.* The alternative of $12\frac{1}{2}$ parts does not agree with remaining directions. A rough sketch of both parts and brick structures are given by Gelder, which do not agree with the textual description. Four types of bricks are used for this purpose. They are square (40 *aṅg.* × 40 *aṅg.*), triangular (30 *aṅg.* × 30 *aṅg.*, 30 $\sqrt{2}$ *aṅg.*), triangular half (30 *aṅg.*, 15 $\sqrt{2}$ *aṅg*, 15 $\sqrt{2}$ *aṅg.*) and five-cornered bricks. There is no mention that the layer is to be covered with 200 bricks.

Chapters 15 and 16

PRAUGACIT, UBHAYATA PRAUGA, SAMŪHYA, DROṆA, RATHACAKRACIT

The descriptions are mostly inadequate for drawing the actual diagrams of *ubhayata prauga, samūhya, droṇa* and *rathacakra* fire-altars These can, however, be understood by reference to Baudhāyana and Āpastamba. For *praugacit* a rectangle of 15 sq. *pu.* is to be drawn, and half of this area is required for the purpose. In the *droṇacit* of 1000 bricks, each layer is constructed with 200 bricks. Of two chariot wheels *(rathacakracit)* of different sizes, one has an area of $7\frac{1}{2}$ sq. *pu.* and the other three times as large.

ABBREVIATION

I. *Manuscripts of śulba-texts and commentaries*

Baudhāyana-Śulbasūtra

B — Manuscript belonging to the Government Sanskrit College, Benares, No. 115, Devanāgarī, consists of 18 parts; one part is on the *śulbasūtra*.

H — Haug collection at Munich.

M — Mackenzie Ms. No. 28 (new number 92) of the Mackenzie collection at the India Office Library, London.

Th — Thibaut's edition.

U — Ujjain manuscript, private collection.

Āpastamba-śulbasūtra

BK — Bürk's edition.

D — Manuscript used by Bürk.

Gr — India Office Library, London, hand written Grantha Ms., vide Catalogue of a Collection of Sanskrit Manuscripts No. 78.

MU — Mysore edition.

S — Government Sanskrit College Library, Benares.

Kātyāyana-śulbasūtra

A — Manuscript No. G. 6145, Asiatic Society of Bengal, Calcutta.

K — Edited in Kāśī Sanskrit Series N°. 120.

P — Edition of Madan Pāṭhaka.

Mānava-śulbasūtra

ASB — Manuscript No. 536, Asiatic Society, Bombay.

G — Van Gelder's edition.

L — Manuscript No 41, (Būhler's collection), India Office Library, London.

N — Manuscript No. Th. 184, National Library, Calcutta.

II. *Sanskrit texts used in the work*

Āśl	*Āpastamba-śulbasūtra*
Bśl	*Baudhāyana-śulbasūtra*
Kāṭh. S	*Kāṭhaka Saṃhitā*
KPS	*Kāṭhaka-Kapiṣṭhala Saṃhitā.*
Kśl	*Kātyāyana-śulbasūtra*
Mait. S	*Maitrāyaṇi Saṃhitā.*
Mśl	*Mānava-śulbasūtra*
Mysore	Mysore edition of the *Āpastamba-śulbasūtra.*
Ṛ V	*Ṛgveda Saṃhitā.*
Śat. Br	*Śatapatha Brāhmaṇa.*
SBE	*Sacred Books of the East.*
Tait S	*Taittiriya Saṃhitā.*
Vāj. S	*Vājasaneyi Saṃhitā.*

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